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Impact of lockdown and school closure on children's health and well-being during the first wave of COVID-19: a rapid review

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Impact of lockdown and school closure on children's health and well-being during the first wave of COVID-19: a rapid review

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Abstract:

Background: The COVID-19 pandemic has had indirect effects on children and young people due to school closures and lockdown. Our aims were to examine the impact of large-scale lockdown and school closure measures to combat COVID-19, on child and adolescent health and well-being.

Methods: A systematic review was carried out by searching five databases until November 2020. Quantitative peer reviewed studies reporting health and well-being outcomes in children (0-18 years), related to the impact of closure measures due to COVID-19 were included. The risk of bias of included studies was assessed by a pair of authors. A descriptive and narrative synthesis was carried out.

Findings: Twenty two studies fulfilled our search criteria and were judged not to have a high risk of bias. Studies from Australia, Spain and China showed an increase in depressive symptoms, and decrease in life satisfaction. A decrease in physical activity and increase in unhealthy food consumption was shown in studies from two countries. There was a decrease in the number of visits to the emergency department in four countries, an increase in mortality in Cameroon, and a decrease by over 50% of immunisations administered in Pakistan. A significant drop of 39% in child protection medical examination referrals during 2020 compared with previous years was found in the United Kingdom, a decrease in allegations of child abuse and neglect by almost one-third due to school closures in Florida, and an increase in the number of children with physical child abuse trauma was found in one centre in the United States.

Interpretation: From available reports, pandemic school closure and lockdown have negative effects on child health and well-being in the short and probably in the long term. We urge governments to take the negative public health consequences into account before adopting restrictive measures in childhood.

Keywords: adolescents; children health; COVID-19; lockdown; school closure, social inequalities

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Tables: 2 (Supplementary material)

Key messages

- School closure and lockdown were measures initially adopted almost worldwide in the first wave to fight the COVID-19 pandemic
- Cohort studies from Australia, Spain and China showed an increase in depressive symptoms in children, and decrease in life satisfaction during school closure and lockdown
- One study documented increased mortality in children in Cameroon, there was a decrease in childhood immunisation in Pakistan
- A significant decrease in the number of child abuse and neglect allegations was found in studies from the United Kingdom and United States
- This review highlights the need to take the negative public health consequences into account before adopting restraining measures in childhood

Introduction

The global COVID-19 pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the largest in the century with almost 100 million confirmed cases and over two million deaths.¹ This virus impacts relatively few children in terms of severe morbidity or mortality, however they experience heightened adversity as governments intervene with drastic social control measures.² Over 1.5 billion children were out of school during the first peak, and economic insecurity has affected the most vulnerable with several potential adverse effects.³

Governments around the world have reacted in variable ways with strategies to mitigate the pandemic. A review on the effect of school closure in the transmission of the SARS-CoV-2 at the general population predicted that school closures alone would prevent only 2–4% of deaths, much less than other social distancing interventions.⁴ On the other hand, school closures carry high social and economic costs for people across communities associated with interrupted learning, poor nutrition, gaps in childcare, unintended strain on health-care systems, rise in dropout rates from school, and social isolation, among other effects.⁵

This is a universal crisis and, for some children, the impact will be lifelong.⁶ Further, in response to school closure many have opted for virtual teaching, further accentuating the digital divide between those who have access and those without access.⁷ Moreover, schools have an influence on every student's health, and have opportunities to advocate for implementation of reforms and innovations in school systems to promote the health of all students, and the linkage between health and education.^{8, 9}

Large-scale "lockdowns" as occurred with little warning in India, involving the complete shutting down of all economic activity, along with stringent travel bans, with punitive action for any violation, have shown to cause disproportionate impact on the most vulnerable populations.¹⁰ Decisions on how to apply quarantine and school closure should be based on the best available evidence. In situations where quarantine is deemed necessary, officials should quarantine individuals no longer than required, provide clear rationale for quarantine and information about protocols, and ensure sufficient supplies are provided.¹¹ In summary, during the fight against coronavirus in several countries, children were being put at risk, in order to reduce the spread of a disease that mainly causes direct harm to adults.¹² The risks are greater and have a potential short- and long-term negative effect, mostly in low- and middle-income countries, and especially in the prenatal and in early childhood periods.¹³

At the current stage of the pandemic we feel that it is important to summarize and compile existing information on the pandemic's impact on child health, and the measures that have been taken. The aim of this rapid review is therefore to study the impact of COVID-19 lockdown measures, and school closures on child and adolescent health and well-being. Our research questions were: a) What impact do large-scale lockdowns and closure of schools have on child health and well-being?; and b) to what extent do these effects of confinement increase social inequalities in child health?

Methods

A rapid systematic literature review was carried out by search in PubMed, Medline, Psycinfo, Web of Science, and Google Scholar, using the following terms: "(Lockdown OR School closure) AND (COVID-19 OR SARS-CoV-2) AND (children OR adolescent) AND (secondary effects OR physical OR mental)". Secondary hand search also was done. The time period analysed was December 1st 2019 until November 24th 2020.

The research questions followed the Population Intervention Comparison Outcome (PICO) tool:¹⁴ P= 0-18 years, I= school closures and /or lockdown due to COVID 19; C= a comparison

group—could be compared to same population before or unexposed population as control, O= physical, developmental or mental health, psychosocial (would include child maltreatment, domestic violence, violence, etc), access and use of healthcare services.

The Preferred Reporting Items of Systematic reviews Meta-Analyses (PRISMA, <http://www.prisma-statement.org/>) guideline was followed, although some items are not applicable given the characteristics of included studies.

The risk of bias of each included study was assessed by a pair of authors (PB, AH, LR) using the Mixed Methods Appraisal Tool (MMAT),¹⁵ and was further stratified as low, intermediate or high risk by consensus of each pair of authors.

Inclusion criteria: All quantitative studies in peer review describing studies that include primary data about child (0-18 years) health and well-being related to the measures adopted regarding of COVID-19 in children younger than 19y and the impact on child health were included, without language restrictions. Original studies (cohort studies, repeated cross-sectional studies, etc) were included if they include data from children. Changes in access/use of healthcare services during lockdown was also included.

Exclusion criteria: Studies that did not present separate data on childhood population, as well as commentaries, theoretical frameworks, without the analysis of empirical data, and pre-print not peer reviewed articles were excluded. Commentaries not based on specific empirical data (opinion papers, protocols, letters without specific reviewed data), articles regarding clinical manifestations as well as school transmission of COVID-19, impact on adults (i.e. teachers, parents, except if it includes specifically secondary impact on children), and cross-sectional studies analyzing retrospective data without comparison or control group were also excluded.

Procedures: Abstracts obtained by the initial search strategy were assessed for possible inclusion by at least two authors. Full text papers of the studies was obtained in doubtful cases and independently assessed by these authors. Differences of opinion on inclusion was decided by discussion and consensus among all authors.

Data extraction: Author; setting (country: international, national or regional study); type of study; age(s); lockdown (severity and time in days/months); school closure and lockdown (time period); type of outcome; impact on child health, and social inequalities.

Analysis: A meta-analysis was not be possible to carry out given the nature of the study design and heterogeneity of the findings. A descriptive and narrative synthesis of the results was carried out.

Results

Study selection and risk of bias.

After the exclusion of one study due to a high risk of bias¹⁶, 22 studies were included in the synthesis (Figure 1). Included studies were from 15 countries, 11 from European countries. Eleven studies were follow-up of children, while the rest of studies analyzed clinical databases, mortality registers, or registries on child abuse and maltreatment (Table 1 Supplementary material).

Almost all of the included studies showed low to moderate risk of bias, except one study that was considered as moderate-high risk of bias; it included a very small sample, administered an

unstructured questionnaire, anthropometric measurements were taken at baseline only, and using measurements not clearly appropriate for age (Table 2 Supplementary material).¹⁷

Exposure measure

School closure was the common measure adopted, although in most countries closure of schools and home confinement were both implemented at the same time; in some cases the latter was established as a mandatory norm and especially for the child population, and in other cases it was established as a general recommendation. The impact of school closure and lockdown was assessed between 2 weeks and 2-3 months after these measures were started.

Outcome measures

Four studies addressed mental health,^{18–21} three studies analyzed physical activity and obesity,^{17,22,23} 12 studies approached changes in the access, and use of healthcare services,^{24,25, 26, 27–33,34,35} while three studies analyzed data regarding child abuse and violence.^{36–38}

Mental health

One Australian study showed significant increases in depressive symptoms and anxiety, and a significant decrease in life satisfaction during school closure and lockdown, mainly in girls compared to boys.¹⁸ A Spanish study gave evidence to worse total difficulties score of the Strengths and Difficulties Questionnaire (SDQ) according to parent-proxy responses.¹⁹ A cohort of Chinese children and adolescents showed that all indicators of depressive symptoms (nonsuicidal self-injury, suicide ideation, suicide plan, and suicide attempt) deteriorated significantly during lockdown compared to previous baseline data.²⁰ No difference in the number of suicides was found in a Japanese study.²¹

Physical activity, obesity

A decrease in physical activity level (PAL) was found in a child cohort from Croatia (from 2.97 to 2.63, $p < 0.01$) and significant differences were observed between adolescents living in urban and rural environments.²² A study from Bosnia & Herzegovina found that 50% of adolescents achieved sufficient PAL at baseline, while 24% at the time of follow-up measurement during lockdown; moreover, paternal level of education was associated to PAL during lockdown (OR: 1.33, 95%CI: 1.19–2.01).²³ The follow-up of Italian obese adolescents found that the number of meals per day increased by 1.15 ± 1.56 ($p < 0.001$) during lockdown and also unhealthy food consumption and sedentary behaviours.¹⁷

Healthcare services access /use

There were no differences in the proportion of Caesarean deliveries (CD) between the observation and control groups in a Chinese study. Further, birth weight in the observation group during lockdown was higher than in the control group among infants born >34 gestational weeks.²⁴

Three studies on children with Type 1 Diabetes Mellitus from Israel,²⁵ Greece,²⁶ and Italy²⁷ (T1DM) showed no changes or even some improvements in glucose control indicators, although in some cases younger age and low family socioeconomic status was associated with worse control during the lockdown period.

In Canada, the number of visits to the emergency department (ED) due to injuries in children decreased in a 2-month period in 2020 compared to the same period from 1993-2019.²⁸ Similarly, referrals to the mental healthcare services for children and adolescents decreased during lockdown in England compared with the previous year.²⁹ An increase in the number of admissions due to seizures was found in an Italian children's hospital.³¹ In another Italian study, the mean pediatric ED daily consultations decreased from 326.3 (95% CI 299.9–352.7) in March–May 2019 to 101.4 (95% CI 77.9–124.9) in the same period in 2020 ($p < 0.001$).³³

Similarly, a decrease in the number of visits by 63·8% to the ED was observed comparing with the same time period in 2019 in a German hospital except for malignant/neoplastic diseases.³² An Australian study found that there was 47·2% decrease in total visits to the ED (26,871 vs 14,170), with a significant difference in daily mean. Conversely, there was a 35% (485 vs 656) increase in mental health diagnoses, while neonatal visits did not change significantly.³⁰

There was a 52·5% decline in the daily average of total number of vaccinations administered during lockdown compared to baseline data in Pakistan.³⁴ A study from Cameroon showed a drastic drop in hospitalizations and mortality rates doubled comparing with the previous year.³⁵

Violence, abuse against children

Routinely collected clinical data on Child Protection Medical Examinations from Birmingham (UK) showed a significant drop of 39% (95% CI 14% to 57%) in child protection medical examination (CPME) referrals during 2020 compared with previous years, mainly associated with decreased school staff referrals.³⁶ A study from the US found an increase in the number of children with physical child abuse trauma,³⁷ and the Florida child abuse allegation data showed a decrease in 27% (n= 15,000) in the number of allegations of child abuse and neglect comparing with the same 2 months of 2019.³⁸

Discussion

The present review provides one of the first summaries of peer-reviewed published evidence on the impact of school closures and lockdown on child health, wellbeing and access to healthcare, during the first wave of COVID-19. The results show worse mental health status of children and adolescents from disparate geography, and a reduction in physical activity and increased sedentary behaviors. There were changes in the access and use of healthcare services as manifested by decreases in the ED visits, increased mortality in the study from Cameroon, and a reduction on immunisation coverage in Pakistan. Finally, an increased risk of child abuse and violence against children due to decreased access to general and specific care services during the period of lockdown and school closure was seen in the US and UK. The effect of these measures of restriction points to an increase in social inequalities, although only a few of the studies have focussed specifically on the analysis of the impact on social determinants of child health. We found a greater negative effect in the most vulnerable groups (i.e. higher mortality and less vaccination coverage in the studies from low and middle income countries), and greater negative impact on mental and physical health and child abuse and maltreatment in the most vulnerable child population in studies from high-income countries.

The results of this “non-natural experiment” are generalizable to most of the countries that applied lockdown or confinement and closure of schools, although each country individually has different healthcare and education systems, and social and redistribution policies. Confinement has produced an increase in previously existing inequalities with respect to access to basic living conditions and care services, with more difficulties in households with fewer resources.

The results of the present study add to previous analyses on the impact of quarantine and school closure during previous epidemic episodes worldwide.¹¹ The latter analyzed the psychological impact and reported negative psychological effects including post-traumatic stress symptoms, confusion, and anger. On the other hand, social isolation exacerbates personal and collective vulnerabilities while limiting accessible and familiar support options.³⁹ Many countries have seen an increase in demand for domestic violence services and reports of

increased risk for children not attending schools, a pattern similar to previous episodes of social isolation associated with epidemics and pandemics.⁴⁰

Another review on the impact of COVID-19 on families and children found an increase in parental stress related to the suspension of classroom activities, social isolation measures, nutritional risks, children's exposure to toxic stress, depressive and anxiety symptoms, especially in previously unstructured homes, and a lack of physical activities.⁴¹ Some cross sectional reports found important differences between households of different socio-economic status regarding home learning and with important potential implications for the long-term impact that the unprecedented circumstances.⁴² Moreover, some studies carried out modelizations on the impact of inequalities and lost school learning. Christakis et al.⁴³ compared the full distribution of estimated years of life lost (YLL) due to COVID-19 under both "schools open" and "schools closed" conditions, and observed a 98·1% probability that school opening would have been associated with a lower total YLL than school closure. On the other hand Azevedo et al.⁴⁴ found that between 0·3 and 0·9 years of schooling losses adjusted for quality, bringing down the effective years of basic schooling that students achieve during their lifetime from 7·9 years to between 7·0 and 7·6 years. This would be associated with lost earnings in the amount between \$6,472 and \$25,680 dollars over a typical student's lifetime, exacerbating inequalities.

Strengths and Limitations

One of the strengths of the present review is the inclusion of peer reviewed, longitudinal data, or repeated cross-sectional data based on comparable measures, making the association between exposure to lockdown and school closure and outcome measures analyzed more robust. Among the limitations to be mentioned are that few of the studies analyzed data from low- and middle-income countries, or social inequalities as independent factors, and this should be addressed in future studies. Second, the exposure measures that we analyzed, both school closure and lockdown, varied between countries and also the period from the beginning of the measures and the time outcomes were assessed. This fact makes it difficult to assess the impact according to the level and duration of confinement and also to establish a clear association between exposure and outcomes. However, all the included studies present at least the timeline for the initiation of the measures adopted and evaluation of the results. Finally, it should be taken into account that measures analyzed here may have long term effects and therefore future studies will need to factor in longer follow up.

Conclusions

This review attempts to provide the best available evidence on the impact of large-scale restrictive measures on child and adolescent health. These results urge a call to attention by decision-makers regarding public health measures that are adopted and the need to apply the precautionary principle, taking into account the risks and benefits for children's health. Policy makers and researchers should look to other much less disruptive social distancing interventions given that lockdown measures greatly affect children and with more negative effects than benefits in the short and probably also in the long term. As other public health experts are urging,⁴⁵ we suggest that a comprehensive public health approach is needed in response to this pandemic, that would address social determinants and medical requirements simultaneously, with equity and human rights as overarching principles.

Contributors

LR, PB, and AH conceptualised the paper, reviewed full-text articles, extracted the data, and wrote the first draft of the manuscript. GG, SR, and OK contributed to searches and screening

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of papers, and helped to revise the paper and consider implications. All authors contributed to revision of the final version of the manuscript.

Declaration of interest

We declare no competing interest

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Figure 1. Flow diagram of Search and Study Inclusion Process

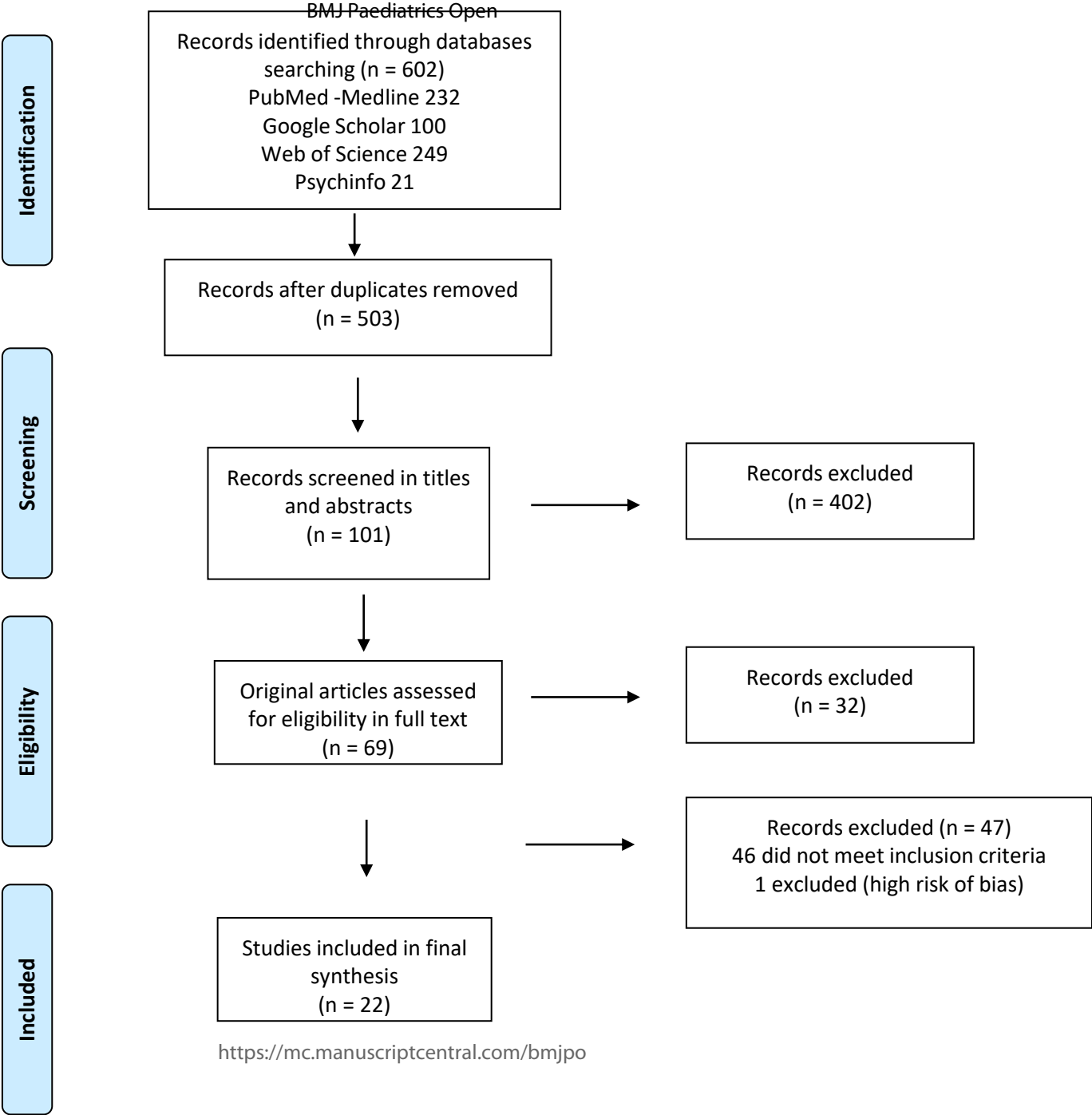


Table 1. Supplementary material. Characteristics of included studies**Mental health, general health**

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Magson NR, et al. (J Youth Adolesc) ¹	Australia (New South Wales)	Cohort study (Risks to Adolescent Wellbeing Project, the RAW Project)	Mental health, life satisfaction	To assess the impact of the COVID-19 pandemic on adolescents' mental health, and moderators of change, as well as assessing the factors perceived as causing the most distress	13-16y (response rate 53% at time T2 during lockdown, n=248)	T1= previous year (2019) T2= 2 months after start lockdown) May 5 to May 14	Generalized Anxiety, Depressive symptoms, Student's Life Satisfaction Scale (SLSS)	Age, sex, schooling, peer and family relationships, social connection, media exposure, COVID-19 related stress, and adherence to government stay-at-home directives at T2	Significant increases in depressive symptoms and anxiety, and a significant decrease in life satisfaction from T1 to T2, higher among girls. Moderators were COVID-19 related worries, online learning difficulties, and increased conflict with parents as predictors of increases in mental health problems from T1 to T2. Adherence to stay-at-home and feeling socially connected during the lockdown protected against poor mental health
Ezpeleta L, et al. (Int J Environ Res Public Health) ²	Barcelona (Spain)	Cohort study (started 10 years ago)	Mental health	To assess life conditions during lockdown associated with mental health problems in Children, and to analyze the mental health status of the population during the lockdown period	226 parents (mainly mothers) answered the questionnaire (response rate 55%). Mean age= 13.9y	Lockdown March 13 to May 24. Questionnaires answered on June. Compare results with 2019	SDQ parent-proxy version	Physical environment, COVID-19 disease, the adults sharing the house, adolescents' relationships, activities, and feelings/behaviors	Total difficulties increased and peer, and prosocial, after adjusting for previous pathology. Effect size small to medium
Zhang L, et al. (JAMA Net Open) ³	China (Chizhou, Anhui Province)	Cohort	Mental health	To investigate psychological symptoms, nonsuicidal self-injury, and suicidal ideation, plans, and attempts among a cohort of	Age range 9-3-15-9. Mean age: 12-6y 4th to 8th grades. N= 1241 out of 1387	2 waves: wave 1, early November 2019; and 2 weeks after school reopening (wave 2, mid-May 2020). After 3 months of lockdown, schools	Data on depressive and anxious symptoms (Mood and Feelings Questionnaire (MFQ); MacArthur Health & Behavior Questionnaire), nonsuicidal self-injury Non-suicidal self-injury	Adjusting for age, sex, body mass index, self-perceived household economic status, family cohesion, parental conflict, academic stress, parental educational level,	The prevalence of mental health outcomes among students in wave 2 increased significantly from levels at wave 1: depressive symptoms (24-9%)

				children and adolescents	participants in 2 waves	in Chizhou were reopened on April 26	(NSSI), suicide ideation, suicide plan, and suicide attempt were collected in 2 waves	family adverse life events, self-perceived health, sleep duration, and sleep disorders.	vs 18.5%; adjusted odds ratio [aOR], 1.50 [95%CI, 1.18-1.90]; nonsuicidal self-injury (42.0% vs 31.8%; aOR, 1.35 [95%CI, 1.17-1.55] ^a ; suicide ideation (29.7% vs 22.5% aOR, 1.32 [95%CI, 1.08-1.62]; suicide plan (14.6% vs 8.7%; aOR, 1.71 [95%CI, 1.31-2.24]; and suicide attempt (6.4% vs 3.0% aOR, 1.74 [95%CI, 1.14-2.67]. No differences in anxiety symptoms
Isumi A, et al. (Child Abuse Negl) ⁴	Japan	Data on mortality by age in Japan	Suicides	To investigate the acute effect of the first wave of the COVID-19 pandemic on suicide among children and adolescents during school closure in Japan.	Total number of suicides among children <20y	School closure March-May 2020. Compare March to May 2020 with the same data on 2018 and 2019	Suicide Incidence rate ratio (IRR) by month		No change in suicide rates during the school closure (incidence rate ratio (IRR) = 1.15, 95% CI: 0.81 to 1.64). And no interaction with school closure

Physical activity, obesity

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Zenic N, et al. (Appl Sci) ⁵	Croatia	Follow-up	Physical activity (PA)	To evaluate the changes in PAL and factors associated with PALs	N= 823; Mean age= 16.5y	“Social distancing measures”: March 15. T1: October 2019 to March 2020 and T2 April 2020	Anthropometrics, physical fitness status, and evaluation of PALs (Physical Activity Questionnaire for Adolescents, PAQA) evaluated by an internet application	Urban vs rural	A decrease in PAL for the total sample (from 2.97 to 2.63, p < 0.01) and mainly in urban adolescents (from 3.11 to 2.68, p < 0.001). Significant differences between adolescents living in urban and rural environments were observed for baseline-PAL.
Gilic B, et al. (Child (Basel)) ⁶	Bosnia &	Follow-up pre and	Physical activity level (PAL)	Changes in PAL among adolescents from Bosnia and Herzegovina and to	N= 688 adolescents (322	Baseline Jan 6-12 Lockdown March 16 Follow-up April 20-26	The Physical Activity Questionnaire for Adolescents (PAQ-A)	Parental education level,	50% of adolescents underwent sufficient PAL at baseline, while only 24% of

	Herzeg ovina	during pandemic		evaluate sociodemographic and parental/familial factors which may influence PAL before and during the COVID-19 pandemic and imposed lockdown	females), mean age 17y at the baseline (15–18y), attending high school. N= 794 baseline F- up= 695			income level, family conflicts	them were achieving sufficient PAL at the time of follow-up measurement. Paternal level of education was associated to PAL during lockdown (OR: 1.33, 95%CI: 1.19–2.01)
Pietrobelli A, et al. (Obesity Spring) ⁷	Italy (verona)	Longitudi nal observati onal study- OBELIX Study	Obesity	To analyze if youths with obesity, when removed from structured school activities and confined to their homes during the COVID-19 pandemic, will display unfavorable trends in lifestyle behaviors	N=41 out of 50. Mean age 13.0±3.1	Children enrolled between May 13th and July 30th, 2019. The interviews were conducted at the baseline visit and again three weeks following the mandatory quarantine starting on March 10th, 2020.	Body weight, height, and waist circumference were measured at the baseline visit; BMI was calculated	Gender differences	The number of meals eaten per day increased by 1.15±1.56, (p<0.001). Sleep time increased significantly (0.65±1.29 hours/day, p=0.003) and sports time decreased significantly by 2.30±4.60 hours/week (p=0.003). Screen time increased by 4.85±2.40 hours/day (p<0.001). There was an inverse correlation between change in sports participation and both a change in number of meals/day and in screen time (r = -0.27, borderline significant at p=0.084). The number of meals eaten per day increased significantly more in the males than in females

Healthcare services access / clinical data

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Li M, et al. (PlosOne) ⁸	China (Wuhan)	Analysis of register of	Perinatal services	To compare the indications for cesarean delivery (CD) and the birth	N= 3,432 (out of 3,442) pregnant women who	On 23 January 2020, the municipal government of Wuhan	Type of delivery. The neonates' data including birth weight, clinical		There was no differences in CD between the observation and control groups. Birth

		perinatal data		weights of newborns during and pre Lockdown	gave birth during lockdown and 7,159 (out of 29799) matched pregnant women before lockdown	announced the lockdown of the entire city. Data was collected until March 14. Control group: from 1 January 2019 to 22 January 2020	symptoms, Apgar score, and outcomes		weight in the observation group was heavier than that in the control group among those with >34 gestational weeks (p<0.05). There was no significant difference in neonatal asphyxia between the two groups
Brener A, et al. (Acta Diabetol) ⁹	Israel	Follow-up	Clinical control of T1D	To assess the impact of COVID-19 lockdown on the glycemic control of pediatric patients with T1D.	102 T1DM patients (52.9% males), mean age 11.2y, mean diabetes duration 4.2y	From February 23, 2020 to March 7, 2020 and during the lockdown from March 25, 2020 to April 7, 2020.	Mean glucose level, time-in-range (TIR, 70–180 mg/dL; 3.9–10 mmol/L), hypoglycemia (< 54 mg/dL; < 3 mmol/L), hyperglycemia (> 250 mg/dL; > 13.3 mmol/L), coefficient of variation (CV), and time CGM active before and during lockdown	Age, sex, households (single/two parents)], socioeconomic position by home address SEP cluster and SEP index	In the younger age group, a multiple linear regression model revealed associations of age and lower SEP cluster with delta-TIR (F = 4.416, P = 0.019) and with delta-mean glucose (F = 4.459, P = 0.018). No sig. correlations were found in the adolescent age group.
Christoforidis A, et al. (Diabetes Res Clin Pract) ¹⁰	Greece	Follow-up	T1DM control	To monitor the effect of the lockdown in glycemic variability, insulin requirements and eating portions and habits in children with T1DM wearing insulin pump equipped with continuous glucose monitoring system	34 out of 250 children with T1DM, mean age= 11.3y	3 weeks before and 3 weeks after March 10 (starting lockdown and school closure)	Control of insulin pump equipped and glucose metabolism		A higher Coefficient of Variation (CV) indicating an increased glucose variability in the pre-lockdown period was observed (39.52% versus 37.40%, p = 0.011). No significant difference was recorded regarding the total daily dose of insulin and the reported carbohydrates consumed, however, meal schedule has changed
Di Dalmazi G, et al. (BMJ Open Diabetes Res Care) ¹¹	Italy (Orsola Policlinic, Bologna)	A cohort of DM-1	Clinical control in diabetics	To investigate continuous glucose monitoring (CGM) metrics in children and adults with T1D during lockdown and to identify their potentially related factors.	130 consecutive patients with T1DM (30 children (≤12 years), 24 teenagers (13–17 years),	Before the lockdown in Italy, from 20 February to 10 March 2020, and also January 30 to February 19 (prelockdown) and 20 days starting from that date, from 11 to 30 March 2020 (during lockdown).	Outcome measures: index of glucose control: GMI, LBG index, etc		In children, significantly lower (improvement) glucose SD (SDglu) (p=0.029) and time below range (TBR)<54 mg/dL (TBR2) (p=0.029) were detected after lockdown. CGM metrics were comparable in teenagers before and during lockdown.

Keays G, et al. (Health Promot Chronic Dis Prev Can) ¹²	Canada (Montreal Children's Hospital)	Data from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP)	Use of healthcare services (ED)	To evaluate if injury-related ED visits during the COVID-19 pandemic decrease	General population stratified by age	Compare data from a two-months period during the COVID-19 lockdown (16 March to 15 May) to the same period in previous years (1993–2019)	Visits to ED due to injuries: motor vehicle collisions, sports-related injuries, and injuries that occurred during recreational activities.	No data	Compared with the 2015–2019 average, the decrease was smallest in children aged 2 to 5 years (35% decrease), and greatest in the group aged 12–17y (83%). More children aged 6 to 17 years presented with less urgent injuries during the COVID-19 lockdown
Tromans S, et al. (Br J Psy Open) ¹³	Leicester -UK	Electronic data register of aprox. 1,000,000 hab of the NHS	Mental health	To describe secondary mental health service utilization prelockdown and during lockdown	Grat population. Children and adolescents' mental healthcare services (CAMHS)	27 Jan–22 March compared to 23 March 17 May (lockdown)	Mental health admissions and referrals		Admissions pre-lockdown n=14; lockdown n= 17, referrals pre-lockdown n = 2193; lockdown n = 1081
Cheek JA, et al. (Emerg Med Australas) ¹⁴	Australia (4 hospitals from Victoria)	Analysis of ED register	Use of healthcare services (ED)	To determine if changes to community-based services have affected paediatric ED attendances for mental health issues and neonates during the COVID-19 pandemic	<18y and neonatal visits	Closure of borders to non-residents on 20th March 2020.	Compare total visits to the ED, visits for mental health diagnoses and neonatal visits		There was 47·2% decrease in total presentations (26871 vs 14170), with significant difference in daily mean. Conversely, there was a 35% (485 vs 656) increase in mental health, while neonatal presentations did not change (2% increase, 498 vs 507)
Palladino F, et al. (Neurol Sci) ¹⁵	Italy. Santobon o-Pausilipon Children's Hospital (Southern Italy)	Repeated cross-sectional study of clinical registers	Clinical health, seizures	To compare the 2020 admissions for seizures at the ED with previous year	Patients (4–14 years) attending the ED for seizures n=57 Median age: 8·03y	Compare March 9 up to May 4 and the same period for 2019	Diagnoses previous (epilepsy) or not	Use of devices, how contact with healthcare services	57 patients 20 of them new patients compared with 13 in 2019 and other differences
Dopfer C, et al. (BMC Pediatr) ¹⁶	Germany (Hanover)	Healthcare services. ED	Registry of pediatric ED	To investigate pediatric emergency healthcare utilization in a tertiary care center	N= 5424 visits in the study period. Mean age 7·1y	School closures beginning on March 16th, and an official lockdown of public life, on March 23rd	Number of visits; ICD-10 diagnoses	Age, sex	In 2020, case numbers decreased by 63·8% compared to the same time period of 2019. The % of

		utilization				2020. Analysis: March 18th to April 14th in 2019 and March 16th to April 12th in 2020.			visits of children <1y increased in 2020. The disease category with increased daily ER visits after the lockdown began was that of malignant/neoplastic disease
Valitutti F, et al. (Front Pediatr) ¹⁷	Italy (Campania region)	Healthcare services use before after	ED registry	To highlight the impact of the COVID-19 pandemic on ED consultation	Mean age = 5.4 y in 2019 and 5.9y in 2020	Registers of trimester March–May 2019 vs. registers of trimester March–May 2020	Number of consultations, diagnoses, causes of emergency visits		Mean pediatric ED daily consultations were 326.3 (95% CI 299.9–352.7) in March–May 2019 and 101.4 (95% CI 77.9–124.9) in March–May 2020 (p < 0.001)
Chandir S, et al. (Vaccine) ¹⁸	Pakistan (Sindh)	Analysis of Electronic Immunization Registry	Healthcare services. Preventive measures (Immunization).	To measure the reduction in daily immunization rates in Sindh province, report antigen-wise coverage, and drop-out rates for 0–23 month children, identify baseline characteristics associated with drop-outs, and observe the spatial distribution of immunization activity.	0–23 month children	Lockdown starting on March 23, 2020, was initially extended to May 9, 2020. It was a complete ban on movement, and exemptions were given only to essential service providers, including health (including immunizations), law enforcement, utility, and telecommunications	Primary outcome of the analysis was the receipt of EPI recommended vaccinations (BCG, polio, penta, PCV10, rotavirus, and measles) during the COVID-19 lockdown period. Analysis of data from September 23, 2019, to July 11, 2020.		There was a 52.5% decline in the daily average total number of vaccinations administered during lockdown compared to baseline. The highest decline was seen for BCG (40.6% (958/2360) immunization at fixed sites. Around 8438 children/day were missing immunization during the lockdown. Enrollments declined furthest in rural districts, urban sub-districts with large slums, and polio-endemic super high-risk sub-districts.
Chelo D, et al. (Pediatr Pathol) ¹⁹	Cameroon	Before after approach	Hospitalization and mortality in the main pediatric hospital in Yaounde	To analyze the consequences of the pandemic on hospitalizations and on mortality in a pediatric hospital.	Children (age not specified) pediatric age	Lockdown started on March 17 th . Analysis: 1st to 30th June, 2020 and covered the period from January 1st, 2016 to May 31st, 2020.	Hospitalization rates and mortality rates by periods		A drastic drop in hospitalizations was noted coinciding with the partial lockdown in Cameroon. At the same time, the number of deaths per month doubled though the causes remained the same as in the past.

Violence, abuse against children

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
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Garstang J, et al. (BMJ Open) ²⁰	UK (Birmingham)	Registry of child protection	Routinely collected clinical data from Child Protection Medical Examination	To determine any change in referral patterns and outcomes in children referred for child protection medical examination (CPME) during the COVID-19 pandemic compared with previous years.	Children (0–18). N= 200 CPME	Data were collected for all CPME for 18-week periods in 2018, 2019 and 2020, from the last week in February to the end of June	Incidence rate ratios (IRR) of CPME comparing 2018–19 and 2020		A significant drop of 39% (95% CI 14% to 57%) in CPME referrals during 2020 compared with previous years. CPME 2018= 78; 2019 =75; 2020= 47. Associated mainly to a school staff decreased in referrals
Kovler ML, et al. (Child Abuse Negl) ²¹	US (Maryland)	Clinical registry (Johns Hopkins Hospital of Maryland)	Child abuse and maltreatment	To assess the proportion of injuries secondary to physical child abuse (PCA) at a level I pediatric trauma center during the Covid-19 pandemic.	Younger than 15y	Childcare facilities closed on March 27. Analysis: March 28 to April 27 and compare with 2018 and 2019	PCA during lockdown	Age, race, severity, type of trauma	8 patients (13% of total trauma) compared to 4 (2019, 4%) and 3 (2018, 3%)
Baron EJ, et al. (J Public Econ) ²²	US (Florida)	Allegation data from the Florida DCF. County-level, monthly information on the total number of allegations of abuse, neglect, or abandonment of children	Child abuse and maltreatment	To analyze the Florida child abuse Hotline reported cases and compare with previous years	Children (not specific age?)	Official statewide stay-at-home order in Florida was April 3, 2020. Compare from January 2004–2019 with March and April 2020 monthly allegations	Number of reported cases associated to schools opened	Ecological data on county level of economic condition	15,000 lower (27%) than expected for these two months

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Table 2 Supplementary material
Mixed Methods Assessment Tool (MMAT) risk of bias
Magson NR, et al. ¹

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		81.8% Caucasian, and middle-high socioeconomic status 79.2%.
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?			X	
	3.3. Are there complete outcome data?			X	Response rate 53% (248 out of 467)
	3.4. Are the confounders accounted for in the design and analysis?			X	
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate risk				

Ezpeleta L, et al. ²

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		Attrition was higher among those in lower SES
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?			X	
	3.3. Are there complete outcome data?			X	55% answered the questionnaires
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate risk				

Zhang L, et al. ³

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		59.3% male
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Low risk				

Chahal R, et al. ²³

Quantitative		Yes	No	Can't tell	Comments
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non-randomized	3.1. Are the participants representative of the target population?		X		190 out of 214 recruited, 17 excluded due to motion and image quality 102 provided complete survey data, 86 had usable resting state data, did not answer 85 adolescents (49 female) mean 11.3 yrs
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?		X		Participants retrospectively rated their levels of emotions and worries in the 3 months before COVID and 2 most recent weeks during the pandemic. Pubertal staging was administered at baseline, not at COVID assessment since the sample had a mean age of 16.5 years during the COVID-19 ECN coherence measure was obtained only at baseline
	3.3. Are there complete outcome data?		X		
	3.4. Are the confounders accounted for in the design and analysis?		X		
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?		X		T1 baseline fMRI, completed a survey in April 3-April 20, 2020 (2.5-4.5 weeks after the pandemic) The interval ranged from 3.7 to 6.5 years (mean 5.2 years)
Risk of bias	High risk. Excluded from the final synthesis				

Isumi A, et al. ⁴

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	No stratification for <10 yrs, 10-14 yrs, and 15-19 yrs
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Physical activity, Obesity

Zenic N, et al. ⁵

Quantitative non-		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?			X	There are no dropouts reported? This is not discussed
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?		X		Self-reported physical activity

randomized	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate. It does not seem altogether unlikely that self-reported measures are affected by the special COVID-19 situation and that those lost to follow-up had different trajectories than those that participated.				

Gilic B, et al. ⁶

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		65% residing in urban centers and follow up testing included adolescents who can use their own technological resources (those who have smart phones, and computers). Regarding socioeconomic status (urban centers, use of technology are a risk to be not representative
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate				

Pietrobelli A, et al. ⁷

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		Verona, Italy, longitudinal observational study (OBELIX). Non-adult participants with obesity (BMI>25 kg/m2) N=41 children, 35 Italy, 4 North Africa, 2 Albania It is a very small sample.
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?		X		Anthropometric measurements at baseline only. No structured questionnaire. Only a survey on eating and sedentary behaviors while the rest of variable collected at baseline
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?		X		
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate -High				

Li M, et al. ⁸

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	Hospital based study (only one hospital) in Hubei Province China (age 18-50 yrs pregnant women)
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Brenner A, et al. ⁹

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?			X	Patient cohort where only one out of six participated. No attrition analysis.
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate. Main outcome measures are calculated within the same individuals. Should not be very sensitive to non-representativity of study population.				

Christoforidis A, et al. ¹⁰

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?			X	Patient cohort of 34 children. A number of exclusion criteria are reported, including "unwillingness" but the number excluded is not reported
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate. Main outcome measures are calculated within the same individuals. Should not be very sensitive to non-representativity of study population.				

Di Dalmazzi G, et al. ¹¹

Quantitative non-randomized	3.1. Are the participants representative of the target population?	Yes	No	Can't tell	Comments
			X		Italy, S.Orsola Policlinic. 130 consecutive patients with T1D wearing CGM system (30 children <12 yrs), 24 teenagers (13-17 yrs), glucose data. The sample size is small. In addition a very selected group (those under CGM monitoring and with sensor use of >70%). So, results cannot be extended to all patients with T1DM
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?			X	
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?		X		Clustering only in adult patients
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate				

Keays G, et al.¹²

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	28 yrs injury related ED visits Montreal Children's Hospital (one hospital), provincially designated pediatric trauma center. The study relied on data from one hospital
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Tromans S, et al.¹³

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Data based on administrative data.
	4.2. Is the sample representative of the target population?			X	Mental health service utilization in UK, Leicester city. Child and adolescent mental health services n=14. The data reported is from a single healthcare trust in England, and thus may not be generalizable to all regions. It was not possible to examine the sociodemographic or clinical factors of patients referred or admitted. It might be considered that patients being admitted to mental health services

					are those with higher or immediate needs. These are all written in limitations
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?			X	N= 14 (small sample size)
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Cheek JA, et al.¹⁴

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study.
	4.2. Is the sample representative of the target population?			X	Australia, pediatric ED visits. Two tertiary and 2 urban district hospitals in Victoria. The data reported from 4 centers, and the numbers of mental health and neonatal presentations are small, not sure to be generalizable
	4.3. Are the measurements appropriate?	X			Pediatric ED presentations. Mental health patients. Neonatal presentations
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Palladino F, et al.¹⁵

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	South Italy, ED of a single center 4-14 years, seizures, n=57, median age 8 yrs The data is from a single center and small sample size, probably not generalizable
	4.3. Are the measurements appropriate?			X	Demographic, seizures semiology, treatment ED data base and medical records MMD (media use) elaborated by adapting others validated questionnaires?

	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Dopfer C, et al.¹⁶

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Ecological register study of total population in catchment area
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low				

Valitutti F, et al.¹⁷

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Ecological register study of total population in catchment area
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?		X		Appropriate, but poorly defined. Dependent on nurses judgement, could easily change over time with decreased load of patients. Decrease in percentage of total number of patients is used as outcome, is not OK. Should be population bases
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Chandir S, et al.¹⁸

Descriptive study		Yes	No	Can't tell	Comments
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	4.1. Is the sampling strategy relevant to address the research question?	X			
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?		X		The study contains data on two levels, region and individual but is analyzed as one level.
Risk of bias	Low for crude analyses of change, Moderate for multivariate analysis.				

Chelo D, et al.¹⁹

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Ecological register study of total population in catchment area
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?	X			Cause of deaths were not registered for those who arrived dead at hospital. This is appropriately discussed
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low				

Violence, abuse against children**Garstang J, et al.**²⁰

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	Most severe (hospital cases) injuries were not included
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			

	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low				

Kovler ML, et al.²¹

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	Maryland, Physical child abuse related injuries (n=8) 75% black, median age 11.5 months. This study is limited by the short period of retrospective review, and thus by the small number of patients included. Both regional and nationwide data would be needed to be compiled, and to determine if the measure taken to fight the Covid-19 pandemic is broadly associated with increased physical child abuse with more certainty.
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Baron EJ, et al.²²

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Study based on administrative data
	4.2. Is the sample representative of the target population?			X	The data come from one State. Difficulties to know whether the results are externally valid and comparable to other counties and the US.
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low- moderate				

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Impact of lockdown and school closure on children's health and well-being during the first wave of COVID-19: a narrative review

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Impact of lockdown and school closure on children's health and well-being during the first wave of COVID-19: a narrative review

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Abstract:

Background: In the context of containment measures against the COVID-19 pandemic the aims were to examine the impact of lockdown and school closures on child and adolescent health and well-being and social inequalities in health.

Methods: Literature review by searching five databases until November 2020. We included quantitative peer-reviewed studies reporting health and well-being outcomes in children (0-18 years) related to closure measures' impact due to COVID-19. A pair of authors assessed the risk of bias of included studies. A descriptive and narrative synthesis was carried out.

Findings: Twenty-two studies, including high-, middle- and low-income countries, fulfilled our search criteria and were judged not to have an increased risk of bias. Studies from Australia, Spain and China showed an increase in depressive symptoms, and decrease in life satisfaction. A decrease in physical activity and increase in unhealthy food consumption was shown in studies from two countries. There was a decrease in the number of visits to the emergency department in four countries, an increase in child mortality in Cameroon, and a decrease by over 50% of immunisations administered in Pakistan. A significant drop of 39% in child protection medical examination referrals during 2020 compared with previous years was found in the United Kingdom, a decrease in allegations of child abuse and neglect by almost one-third due to school closures in Florida, and an increase in the number of children with physical child abuse trauma was found in one centre in the United States.

Interpretation: From available reports, pandemic school closure and lockdown have adverse effects on child health and well-being in the short- and probably long-term. We urge governments to take the negative public health consequences into account before adopting restrictive measures in childhood.

Keywords: adolescents; children health; COVID-19; lockdown; school closure, social inequalities

Number of words in the text: 3065
Number of word in the abstract: 284
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Figures: 1
Tables: 5

What is already known

- School closure and lockdown were measures initially adopted almost worldwide in the first wave to fight the COVID-19 pandemic
- Lockdown and school closure cause disproportionate impacts on the most vulnerable populations
- Decisions on how to apply quarantine and school closures should be based on the best available evidence

What this study adds

- The negative impact of school closures and lockdown has been felt by children across diverse geographies, involving high and low income settings

- Containment measures have produced a range of adverse effects including an increase in depressive symptoms, decrease in satisfaction with life, decrease in immunisation and an increase in unhealthy lifestyle
- Along with a decrease in emergency presentations, there was also a significant decrease in the number of child abuse and neglect allegations and child protection medical assessments

Confidential: For Review Only

Introduction

The global COVID-19 pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the largest since the Spanish flu pandemic in 1918, with almost 100 million confirmed cases and over two million deaths.¹ This virus impacts relatively few children in terms of severe morbidity or mortality; however, they experience heightened adversity as governments intervene with drastic social control measures.² Over 1.5 billion children were out of school during the first peak, and economic insecurity has affected the most vulnerable, with several potential adverse effects.³

Governments around the world have reacted in variable ways with strategies to mitigate the pandemic. A review on the effect of school closure in the transmission of the SARS-CoV-2 in the general population predicted that school closures alone would prevent only 2–4% of deaths, much less than other social distancing interventions.⁴ On the other hand, school closures carry high social and economic costs for people across communities associated with interrupted learning, poor nutrition, gaps in childcare, the unintended strain on healthcare systems, rise in dropout rates from school, and social isolation, among other effects.⁵

The pandemic is a universal crisis that has affected all population groups across the globe. For some children, the impact could be lifelong, particularly the most vulnerable groups and those with less economic, educational and social resources.⁶ In response to school closures and depending on settings, online teaching accentuated the digital divides between those who have access and those without access.⁷ Moreover, schools have health promotion potential by implementing diverse health interventions and opportunities to advocate for reforms and innovations to promote all students' health.⁸ Arguments over whether to close schools or not to prevent transmission during a pandemic need to weigh in the potential health promotional benefits for children by attending school, in particular those in vulnerable situations. This disconnect needs to be addressed with closer cooperation that would revitalize not only their educational potential but also child and adolescent health and wellbeing^{9, 10}

Large-scale “lockdowns” as occurred with little warning in many countries, involving the complete shutting down of all economic activity, along with stringent travel bans, with punitive action for any violation, have been shown to cause disproportionate impact on the most vulnerable populations, e.g., in India.¹¹ Decisions on how to apply quarantine and school closure should be based on the best available evidence. In situations where quarantine is deemed necessary, officials should quarantine individuals no longer than required, provide clear rationale for quarantine and information about protocols, and ensure sufficient supplies are provided.¹² In summary, during the fight against coronavirus in several countries, while adopting social distancing measures in order to reduce the spread of a disease that mainly causes direct harm to adults, children’s needs have not been taken into due consideration.¹³ For children, the risks of such measures might be greater and have a potential for short- and long-term negative effect, mostly in low- and middle-income countries, but also in high-income countries, and especially in the prenatal and in early childhood periods.¹⁴

At the current stage of the pandemic it is important to summarize and compile existing information on the pandemic’s impact on child health given the measures that have been taken. The aim of this narrative review is therefore to study the impact of COVID-19 lockdown measures and school closures on child and adolescent health and well-being. Our research questions were: a) What impact do lockdowns and closure of schools have on child health and well-being?; and b) to what extent do the effects of confinement increase social inequalities in child health?

Methods

A literature review was carried out by search in PubMed, Medline, Psychinfo, Web of Science, and Google Scholar, using the following terms: “(Lockdown OR School closure) AND (COVID-19 OR SARS-CoV-2) AND (children OR adolescent) AND (secondary effects OR physical OR mental)”. Secondary hand search also was done. The time period analyzed was December 1th 2019 until November 24th 2020.

The research questions followed the Population Intervention Comparison Outcome (PICO) tool:¹⁵ P= 0-18 years, I= school closures and /or lockdown due to COVID 19; C= a comparison group—could be compared to same population before or unexposed population as control, O= physical, developmental or mental health, psychosocial (would include child maltreatment, domestic violence, violence, etc), access and use of healthcare services.

The Preferred Reporting Items of Systematic reviews Meta-Analyses (PRISMA, <http://www.prisma-statement.org/>) guideline was followed, although some items were not applicable given the characteristics of included studies.

The risk of bias of each included study was assessed by a pair of authors (PB, AH, LR) using the Mixed Methods Appraisal Tool (MMAT),¹⁶ and was further stratified as low, intermediate or high risk by consensus of each pair of authors. In the first step the risk of bias of each study was independently assessed, and in the second step a consensus was achieved according to the number and characteristics of negative scores.

Inclusion criteria: All quantitative studies from peer review literature describing studies that provided primary data about child (0-18 years) health and well-being related to the measures of school closure and any level of lockdown adopted regarding of COVID-19 and the impact on child health were included. Articles in Catalan, Danish, English, French, German, Icelandic, Italian, Norwegian, Spanish, Portuguese, Swedish and Turkish were included in the first screening. Following the initial screening, all included articles in the study were published in English language journals. Original studies (cohort studies, repeated cross-sectional studies, etc.) were included if they reported children's data. We also included studies on changes in access/use of healthcare services during a lockdown.

Exclusion criteria: Studies that did not present separate data on childhood population, as well as commentaries, theoretical frameworks, without the analysis of empirical data, and pre-print not peer-reviewed articles were excluded. Comments not based on specific empirical data (e.g., opinion papers, protocols, letters without specific reviewed data) were also left out. Further, articles regarding clinical manifestations and school transmission of COVID-19 impact on adults (i.e. teachers, parents, except if it included specifically secondary impact on children), and cross-sectional studies analyzing retrospective data without comparison or control group were also excluded.

Procedures: Abstracts obtained by the initial search strategy were assessed for possible inclusion by at least two authors. Full-text papers of the studies were obtained in doubtful cases and independently evaluated by the authors. Differences of opinion on inclusion was decided by discussion and consensus among all authors (i.e., one study that was initially included in the first screening was excluded by agreement of the authors due to a high risk of bias associated to the type of study and data collection; see the Supplementary material).

Data extraction: LR led data extraction that was checked initially by AH and PB, followed by a consensus with the rest of the authors. Data extraction included a summary of findings to answer the research questions and characteristics of the included studies: author; setting

(country: international, national or regional study); type of study; age(s); lockdown (time in days/months); school closure and lockdown (time period); type of outcome; impact on child health, and social inequalities.

Analysis: A meta-analysis was not possible to carry out given the nature of the study design and heterogeneity of the findings. Consequently, the authors carried out a descriptive and narrative synthesis of the results. First, studies were grouped according to their main subject and methodological similarities. LR, AH, and PB identified the thematic content and described the results, followed by discussion among all the authors. The results were then analysed and summarised to distill out findings to subsequently integrate those with the rest of studies.

Results

Study selection and risk of bias.

After excluding one study due to a high risk of bias¹⁷, 22 studies were included in the synthesis (Figure 1). Included studies were from 15 countries, thereof 11 European. Eleven studies were a follow-up of children, while the rest of the studies analyzed clinical databases, mortality registers, or registries on child abuse and maltreatment.

Almost all of the included studies showed low to moderate risk of bias, except one study that was considered as moderate-high risk of bias; the sample was small, an unstructured questionnaire was administered, anthropometric measurements were taken at baseline only, and measures used were not appropriate for age (Table 1 Supplementary material).¹⁸

Exposure measure (Box 1)

School closure was the most commonly adopted restrictive measure, although in most countries closure of schools and home confinement were both implemented at the same time; in some cases the latter was established as a mandatory norm and especially for the child population, and in other cases it was given as a general recommendation. The impact of school closure and lockdown or any measure of restriction such as stay-at-home, mandatory or recommended, was assessed between 2 weeks and 2-3 months after implementing these measures.

Box 1. Definitions of lockdown and school closure

- Although the term lockdown is not well-defined, it is used to nominate any measure adopted to contain the pandemic employing social distancing measures
- Lockdown measures range considerably, from mandatory total confinement in the home during prolonged periods to be only a recommendation to reduce social interactions and avoid non-essential work as much as possible
- School closure and online classes or home-schooling was the measure adopted in almost all cases during the first wave of the COVID-19 for primary and secondary schools in all included studies

Outcome measures

Five studies addressed mental health,^{19–23} three studies analyzed physical activity and obesity,^{18,24,25} three studies examined diabetes mellitus,^{26–28} eight studies approached changes in the access and use of healthcare services,^{29–36} while three studies analysed data regarding child abuse and violence.^{37–39}

Mental health (Table 1)

One Australian study showed a significant increase in depressive symptoms and anxiety and a significant decrease in life satisfaction during school closure and lockdown, mainly in girls.¹⁹ A

Spanish study gave evidence to a worse total difficulties score of the Strengths and Difficulties Questionnaire (SDQ) according to parent-proxy responses.²⁰ A cohort of Chinese children and adolescents showed that all indicators of depressive symptoms (nonsuicidal self-injury, suicide ideation, a suicide plan, and suicide attempt) deteriorated significantly during lockdown compared to previous baseline data.²¹ No difference in the number of suicides was found in a Japanese study.²² Referrals to the mental healthcare services for children and adolescents decreased during the lockdown in England compared with the previous year.²³

Physical activity, obesity (Table 2)

A decrease in physical activity level (PAL) was found in a child cohort from Croatia (from 2.97 to 2.63, $p < 0.01$) and significant differences were observed between adolescents living in urban and rural environments.²⁴ A study from Bosnia & Herzegovina found that 50% of adolescents achieved sufficient PAL at baseline, while 24% at the time of follow-up measurement during lockdown; moreover, paternal education level was associated with PAL during lockdown (OR: 1.33, 95% CI: 1.19–2.01).²⁵ The follow-up of Italian obese adolescents found that the number of meals per day increased by 1.15 ± 1.56 ($p < 0.001$) during the lockdown and also unhealthy food consumption and sedentary behaviours.¹⁸

Diabetes mellitus (Table 3)

Three studies on children with Type 1 Diabetes Mellitus (T1DM) from Israel,²⁶ Greece,²⁷ and Italy²⁸ showed no changes or improvements in glucose control indicators. However, in some cases, younger age and low family socioeconomic status was associated with worse control during the lockdown period.

Healthcare services access/use (Table 4)

There were no differences in the proportion of Caesarean deliveries (CD) between the observation and control groups in a Chinese study. Further, birth weight in the observation group during lockdown was higher than in the control group among infants born > 34 gestational weeks.²⁹

In Canada, the number of visits to the emergency department (ED) due to injuries in children decreased in 2 months in 2020 compared to the same period from 1993-2019.³⁰ An increase in the number of admissions due to seizures was found in an Italian children's hospital.³² In another Italian study, the mean pediatric ED daily consultations decreased from 326.3 (95% CI 299.9–352.7) in March-May 2019 to 101.4 (95% CI 77.9–124.9) in the same period in 2020 ($p < 0.001$).³⁴

Similarly, a decrease in the number of visits by 63.8% to the ED was observed compared with the same period in 2019 in a German hospital except for malignant/neoplastic diseases.³³ An Australian study found a 47.2% decrease in total visits to the ED (26,871 vs 14,170), with a significant difference in daily mean. Conversely, there was a 35% (485 vs 656) increase in mental health diagnoses, while neonatal visits did not change significantly.³¹

There was a 52.5% decline in the daily average of the total number of vaccinations administered during lockdown than baseline data in Pakistan.³⁵ A study from Cameroon showed a drastic drop in hospitalizations, and child mortality rates doubled comparing with the previous year.³⁶

Violence, abuse against children (Table 5)

Routinely collected clinical data on Child Protection Medical Examinations from Birmingham (UK) showed a significant drop of 39% (95% CI 14% to 57%) in child protection medical examination (CPME) referrals during 2020 compared with previous years, mainly associated

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with decreased school staff referrals.³⁷ A study from the US found an increase in the number of children with physical child abuse trauma,³⁸ and the Florida child abuse allegation data showed a decrease in 27% (n= 15,000) in the number of allegations of child abuse and neglect comparing with the same two months of 2019.³⁹

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Table 1. Studies on mental health and general health

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
NR, et al. (J Youth Adolesc)	Australia (New South Wales)	Cohort study (Risks to Adolescent Wellbeing Project, the RAW Project)	Mental health, life satisfaction	To assess the impact of the COVID-19 pandemic on adolescents' mental health, and moderators of change, as well as assessing the factors perceived as causing the most distress.	13-16y (response rate 53% at time T2 during lockdown, n=248)	T1= previous year (2019) T2= 2 months after start lockdown) May 5 to May 14	Generalized Anxiety, Depressive symptoms, Student's Life Satisfaction Scale (SLSS)	Age, sex, schooling, peer and family relationships, social connection, media exposure, COVID-19 related stress, and adherence to government stay-at-home directives at T2	Significant increase in depressive symptoms and anxiety, and a significant decrease in life satisfaction from T1 to T2, higher among girls. Moderators were COVID-19 related worries, online learning difficulties, and increased conflict with parents as predictors of increases in mental health problems from T1 to T2. Adherence to stay-at-home and feeling socially connected during the lockdown protected against poor mental health.
Ezpeleta L, et al. (Int J Environ Res Public Health) ²⁰	Barcelona (Spain)	Cohort study (started 10 years ago)	Mental health	To assess life conditions during lockdown associated with mental health problems in children, and to analyze the mental health status of the population during the lockdown period.	226 parents (mainly mothers) answered the questionnaire (response rate 55%). Mean age= 13.9y	Lockdown March 13 to May 24. Questionnaires answered on June. Compare results with 2019	SDQ parent-proxy version	Physical environment, COVID-19 disease, the adults sharing the house, adolescents' relationships, activities, and feelings/behaviors	Total difficulties increased and peer, and prosocial, after adjusting for previous pathology. Effect size small to medium.
Zhang L, et al. (JAMA Net Open) ²¹	China (Chizhou, Anhui Province)	Cohort	Mental health	To investigate psychological symptoms, nonsuicidal self-injury, and suicidal ideation, plans, and attempts among a cohort of children and adolescents	Age range 9:3-15:9. Mean age: 12.6y 4th to 8th grades. N= 1241 out of 1387 participant	2 waves: wave 1, early November 2019; and 2 weeks after school reopening (wave 2, mid-May 2020). After 3 months of lockdown, schools in Chizhou were reopened	Data on depressive and anxious symptoms (Mood and Feelings Questionnaire (MFQ); MacArthur Health & Behavior Questionnaire), nonsuicidal self-injury (NSSI), suicide ideation, suicide plan, and suicide	Adjusting for age, sex, body mass index, self-perceived household economic status, family cohesion, parental conflict, academic stress, parental educational level, family adverse life events, self-perceived health, sleep	The prevalence of mental health outcomes among students in wave 2 increased significantly from levels at wave 1: depressive symptoms (24.9% vs 18.5%; adjusted odds ratio [aOR], 1.50 [95% CI, 1.18-1.90]; nonsuicidal self-injury

					s in 2 waves	on April 26	attempt were collected in 2 waves	duration, and sleep disorders.	(42.0% vs 31.8%; aOR, 1.35 [95% CI, 1.17-1.55]°; suicide ideation (29.7% vs 22.5% aOR, 1.32 [95%CI, 1.08-1.62]; suicide plan (14.6% vs 8.7%; aOR, 1.71 [95% CI, 1.31-2.24]; and suicide attempt (6.4% vs 3.0% aOR, 1.74 [95% CI, 1.14-2.67]. No differences in anxiety symptoms.
Tromans S, et al. (Br J Psy Open) ²³	Leicester -UK	Electronic data register of aprox. 1,000,000 hab of the NHS	Mental health	To describe secondary mental health service utilization prelockdown and during lockdown	Grat population. Children and adolescents' mental healthcare services (CAMHS)	Jan 27-March 22 compared to 23 March 23, May 17 (lockdown)	Mental health admissions and referrals		Admissions pre-lockdown n=14; lockdown n=17, referrals pre-lockdown n=2193; lockdown n=1081.
Isumi A, et al. (Child Abuse Negl) ²²	Japan	Data on mortality by age in Japan	Suicides	To investigates the acute effect of the first wave of the COVID-19 pandemic on suicide among children and adolescents during school closure in Japan.	Total number of suicides among children <20y	School closure March-May 2020. Compare March to May 2020 with the same data on 2018 and 2019	Suicide Incidence rate ratio (IRR) by month		No change in suicide rates during the school closure (incidence rate ratio (IRR)=1.15, 95% CI: 0.81 to 1.64) and no interaction with school closure.

Table 2. Studies on physical activity/obesity studies

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Zenic N, et al. (Appl Sci) ²⁴	Croatia	Follow-up	Physical activity (PA)	To evaluate the changes in PAL and factors associated with PALs	N= 823; Mean age=16.5y	“Social distancing measures”: March 15. T1: October 2019 to March 2020 and T2 April 2020	Anthropometrics, physical fitness status, and evaluation of PALs (Physical Activity Questionnaire for Adolescents, PAQA) evaluated by an internet application	Urban vs rural	A decrease in PAL for the total sample (from 2.97 to 2.63, $p<0.01$) and mainly in urban adolescents (from 3.11 to 2.68, $p<0.001$). Significant differences between adolescents living in urban and rural environments were observed for baseline-PAL.
Gilic B, et al. (Child (Basel)) ²⁵	Bosnia & Herzegovina	Follow-up pre and during pandemic	Physical activity level (PAL)	Changes in PAL among adolescents from Bosnia and Herzegovina and to evaluate sociodemographic and parental/familial factors which may influence PAL before and during the COVID-19 pandemic and imposed lockdown.	N= 688 adolescents (322 females), mean age 17y at the baseline (15–18y), attending high school. N=794 baseline F-up= 695	Baseline Jan 6-12 Lockdown March 16 Follow-up April 20-26	The Physical Activity Questionnaire for Adolescents (PAQ-A)	Parental education level, income level, family conflicts	50% of adolescents underwent sufficient PAL at baseline, while only 24% of them were achieving sufficient PAL at the time of follow-up measurement. Paternal level of education was associated to PAL during lockdown (OR: 1.33, 95% CI: 1.19–2.01).
Pietrobelli A, et al. (Obesity Spring) ¹⁸	Italy (verona)	Longitudinal observational study-OBELIX Study	Obesity	To analyze if youths with obesity, when removed from structured school activities and confined to their homes during the COVID-19 pandemic, will display unfavorable trends in lifestyle behaviors.	N=41 out of 50. Mean age 13.0±3.1y	Children enrolled between May 13th and July 30th, 2019. The interviews were conducted at the baseline visit and again three weeks following the mandatory quarantine starting on March 10th, 2020.	Body weight, height, and waist circumference were measured at the baseline visit; BMI was calculated	Gender differences	The number of meals eaten per day increased by 1.15 ± 1.56 ($p<0.001$). Sleep time increased significantly (0.65 ± 1.29 hours/day, $p=0.003$) and sports time decreased significantly by 2.30 ± 4.60 hours/week ($p=0.003$). Screen time increased by 4.85 ± 2.40 hours/day ($p<0.001$). There was an inverse correlation between change in sports participation and both a change in number of meals/day and in screen time

									($r=-0.27$, borderline significant at $p=0.084$). The number of meals eaten per day increased significantly more in the males than in females.
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Table 3. Studies on diabetes mellitus

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Brener A, et al. (Acta Diabetol) ²⁶	Israel	Follow-up	Clinical control of T1D	To assess the impact of COVID-19 lockdown on the glycemic control of pediatric patients with T1D.	102 T1DM patients (52.9% males), mean age 11.2y, mean diabetes duration 4.2y	From February 23, 2020 to March 7, 2020 and during the lockdown from March 25, 2020 to April 7, 2020.	Mean glucose level, time-in-range (TIR, 70–180 mg/dL; 3.9–10 mmol/L), hypoglycemia (<54 mg/dL; <3 mmol/L), hyperglycemia (>250 mg/dL; >13.3 mmol/L), coefficient of variation (CV), and time CGM active before and during lockdown.	Age, sex, households (single/two parents)], socioeconomic position by home address SEP cluster and SEP index	In the younger age group, a multiple linear regression model revealed associations of age and lower SEP cluster with delta-TIR ($F = 4.416$, $p=0.019$) and with delta-mean glucose ($F = 4.459$, $p=0.018$). No significant correlations were found in the adolescent age group.
Christoforidis A, et al. (Diabetes Res Clin Pract) ²⁷	Greece	Follow-up	T1DM control	To monitor the effect of the lockdown in glycemic variability, insulin requirements and eating portions and habits in children with T1DM wearing insulin pump equipped with a continuous glucose monitoring system	34 out of 250 children with T1DM, mean age= 11.3y	3 weeks before and 3 weeks after March 10 (starting lockdown and school closure)	Control of insulin pump equipped and glucose metabolism		A higher Coefficient of Variation (CV) indicating an increased glucose variability in the pre-lockdown period was observed (39.52% versus 37.40%, $p=0.011$). No significant difference was recorded regarding the total daily dose of insulin and the reported carbohydrates consumed, however, meal schedule has changed.
Di Dalmazi G, et al. (BMJ Open Diabetes Res Care) ²⁸	Italy (Orsola Policlinic, Bologna)	A cohort of DM-1	Clinical control in diabetics	To investigate continuous glucose monitoring (CGM) metrics in children and adults with T1D during lockdown and to identify their	130 consecutive patients with T1DM (30 children (≤12 years), 24	Before the lockdown in Italy, from 20 February to 10 March 2020, and also January 30 to February 19 (pre-lockdown) and 20 days starting from that date,	Outcome measures: index of glucose control: GMI, LBG index, etc		In children, significantly lower (improvement) glucose SD (SDglu) ($p=0.029$) and time below range (TBR) <54 mg/dL (TBR2) ($p=0.029$) were detected after lockdown. CGM metrics

				potentially related factors.	teenagers (13–17 years),	from 11 to 30 March 2020 (during lockdown).			were comparable in teenagers before and during lockdown.
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Table 4. Studies on accessing healthcare services

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Li M, et al. (PlosOne) ²⁹	China (Wuhan)	Analysis of register of perinatal data	Perinatal services	To compare the indications for cesarean delivery (CD) and the birth weights of newborns during and pre-lockdown	N= 3,432 (out of 3,442) pregnant women who gave birth during lockdown and 7,159 (out of 29,799) matched pregnant before lockdown.	On January 23 2020, the municipal government of Wuhan announced the lockdown of the entire city. Data was collected until March 14. Control group: from January 1, 2019 to January 22, 2020.	Type of delivery. The neonates' data including birth weight, clinical symptoms, Apgar score, and outcomes		There was no differences in CD between the observation and control groups. Birth weight in the observation group was heavier than that in the control group among those with >34 gestational weeks (p<0.05). There was no significant difference in neonatal asphyxia between the two groups.
Keays G, et al. (Health Promot Chronic Dis Prev Can) ³⁰	Canada (Montreal Children's Hospital)	Data from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP)	Use of healthcare services (ED)	To evaluate if injury-related ED visits during the COVID-19 pandemic decrease.	General population stratified by age	Compare data from a two-months period during the COVID-19 lockdown (March 16 to May 15) to the same period in previous years (1993–2019).	Visits to ED due to injuries: motor vehicle collisions, sports-related injuries, and injuries that occurred during recreational activities.	No data	Compared with the 2015-2019 average, the decrease was smallest in children aged 2 to 5 years (35% decrease), and greatest in the group aged 12-17y (83%). More children aged 6 to 17 years presented with less urgent injuries during the COVID-19 lockdown.
Cheek JA, et al. (Emerg Med Australas) ³¹	Australia (4 hospitals from Victoria)	Analysis of ED register	Use of healthcare services (ED)	To determine if changes to community-based services have affected paediatric ED attendances for mental health issues and neonates during the COVID-19 pandemic.	<18y and neonatal visits	Closure of borders to non-residents on March 20 th 2020.	Compare total visits to the ED, visits for mental health diagnoses and neonatal visits.		There was 47.2% decrease in total presentations (26,871 vs 14,170), with significant difference in daily mean. Conversely, there was a 35% (485 vs 656) increase in mental health, while neonatal presentations did not change (2% increase, 498 vs 507).

Palladino F, et al. (Neurol Sci) ³²	Italy. Santobono-Pausilipon Children's Hospital (Southern Italy)	Repeated cross-sectional study of clinical registers	Clinical health, seizures	To compare the 2020 admissions for seizures at the ED with previous year	Patients (4–14 years) attending the ED for seizures n=57 Median age: 8.03y	Compare March 9 to up to May 4 and the same period for 2019	Diagnoses previous (epilepsy) or not	Use of devices, how contact with healthcare services	57 patients 20 of them new patients compared with 13 in 2019 and other differences.
Dopfer C, et al. (BMC Pediatr) ³³	Germany (Hanover)	Healthcare services. ED utilization	Registry of pediatric ED	To investigate pediatric emergency Healthcare utilization in a tertiary care center	N= 5424 visits in the study period. Mean age 7.1y	School closures beginning on March 16th, and an official lockdown of public life, on March 23 rd 2020. Analysis: March 18th to April 14th in 2019 and March 16th to April 12th in 2020.	Number of visits; ICD-10 diagnoses	Age, sex	In 2020, case numbers decreased by 63.8% compared to the same period of 2019. The % of visits to children <1y increased in 2020. The disease category with increased daily ER visits after the lockdown began was malignant/ neoplastic disease.
Valitutti F, et al. (Front Pediatr) ³⁴	Italy (Campania region)	Healthcare services use before after	ED registry	To highlight the impact of the COVID-19 pandemic on ED consultation	Mean age = 5.4 y in 2019 and 5.9y in 2020	Registers of trimester March-May 2019 vs. registers of trimester March-May 2020	Number of consultations, diagnoses, causes of emergency visits		Mean pediatric ED daily consultations were 326.3 (95% CI 299.9–352.7) in March–May 2019 and 101.4 (95% CI 77.9–124.9) in March–May 2020 (p < 0.001).
Chandir S, et al. (Vaccine) ³⁵	Pakistan (Sindh)	Analysis of Electronic Immunization Registry	Healthcare services. Preventive measures. Immunization	To measure the reduction in daily immunization rates in Sindh province, report antigen-wise coverage, and dropout rates for 0–23 month children, identify baseline characteristics associated with dropout, and observe the spatial distribution of immunization activity.	0–23 month children	Lockdown starting on March 23, 2020, was initially extended to May 9, 2020. It was a complete ban on movement, and exemptions were given only to essential service providers, including health (including immunization), law enforcement, utility, and telecommunications.	Primary outcome of the analysis was the receipt of EPI recommended vaccinations (BCG, polio, penta, PCV10, rotavirus, and measles) during the COVID-19 lockdown period. Analysis of data from September 23, 2019, to July 11, 2020.		There was a 52.5% decline in the daily average total number of vaccinations administered during lockdown compared to baseline. The highest decline was seen for BCG (40.6% (958/2360) immunization at fixed sites. Around 8438 children/day were missing immunization during the lockdown. Enrollments declined furthest in rural districts, urban sub-districts with large slums, and polio-endemic super high-risk sub-districts.
Chelo D, et al. (Pediatr Pathol) ³⁶	Cameroon	Before after approach	Hospitalization and mortality in the main	To analyze the consequences of the pandemic on	Children (age not specified) pediatric age	Lockdown started on March 17 th .	Hospitalization rates and mortality rates by periods		A drastic drop in hospitalization was noted coinciding with partial lockdown. At the same time, the

			pediatric hospital in Yaounde	hospitalization and on mortality in a pediatric hospital.		Analysis: 1st to 30th June, 2020 and covered the period from January 1st, 2016 to May 31st, 2020.			number of deaths per month doubled though the causes remained the same as in the past.
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Table 5. Studies on child abuse

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Garstang J, et al. (BMJ Open) ³⁷	UK (Birmingham)	Registry of child protection	Routinely collected clinical data from Child Protection Medical Examination	To determine any change in referral patterns and outcomes in children referred for child protection medical examination (CPME) during the COVID-19 pandemic compared with previous years.	Children (0–18). N= 200 CPME	Data were collected for all CPME for 18-week periods in 2018, 2019 and 2020, from the last week in February to the end of June	Incidence rate ratios (IRR) of CPME comparing 2018–19 and 2020		A significant drop of 39% (95% CI 14% to 57%) in CPME referrals during 2020 compared with previous years. CPME 2018= 78; 2019=75; 2020= 47. Associated mainly to a school staff decreased in referrals.
Kovler ML, et al. (Child Abuse Negl) ³⁸	US (Maryland)	Clinical registry (Johns Hopkins Hospital of Maryland)	Child abuse and maltreatment	To assess the proportion of injuries secondary to physical child abuse (PCA) at a level I pediatric trauma center during the Covid-19 pandemic.	Younger than 15y	Childcare facilities closed on March 27. Analysis: March 28 to April 27 and compare with 2018 and 2019	PCA during lockdown	Age, race, severity, type of trauma	8 patients (13% of total trauma) compared to 4 (2019, 4%) and 3 (2018, 3%).
Baron EJ, et al. (J Public Econ) ³⁹	US (Florida)	Allegation data from the Florida DCF. County-level, monthly information on the total number	Child abuse and maltreatment	To analyze the Florida child abuse Hotline reported cases and compare with previous years	Children (not specific age?)	Official statewide stay-at-home order in Florida was April 3, 2020. Compare from January 2004–2019 with March and April 2020 monthly allegations	Number of reported cases associated to schools opened	Ecological data on county level of economic condition	15,000 lower (27%) than expected for these two months.

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Discussion

This narrative review provides summaries of peer-reviewed published evidence on the impact of school closures and lockdown on child health, well-being and access to healthcare, during the first wave of COVID-19. The results show worse mental health status of children and adolescents from disparate geography and socioeconomic background, reduced physical activity and increased sedentary behaviors. There were changes in the access and use of healthcare services as manifested by decrease in the ED visits, increased child mortality in a study from Cameroon, and a reduction on immunization coverage in Pakistan. Finally, an increased risk of child abuse and violence against children due to decreased access to general and specific care services during the period of lockdown and school closure was seen in the US and UK. The effect of these measures of restriction indicates an increase in social inequalities. However, only a few of the studies focus specifically on analyzing the impact on social determinants of child health. We found a significant negative effect in the most vulnerable groups (i.e. higher mortality and less vaccination coverage in the studies from low- and middle-income countries), and more significant negative impact on mental and physical health and child abuse and maltreatment in the most vulnerable child population in studies from high-income countries.

The results of this “non-natural experiment” are generalizable to most of the countries that applied any level of lockdown or confinement and closure of schools, although each country has different healthcare and education systems, and social and redistribution policies. Confinement has produced an increase in previously existing inequalities with respect to access to basic living conditions and care services, with more difficulties in households with fewer resources.⁴⁰

The results of the present study add to previous analyses on the impact of quarantine and school closure during previous epidemic outbreaks worldwide.¹² The latter analyzed the impact and reported negative psychological effects including post-traumatic stress symptoms, confusion, and anger. On the other hand, social isolation exacerbates personal and collective vulnerabilities while limiting accessible and familiar support options.⁴¹ Many countries have seen an increase in demand for domestic violence services and reports of increased risk for children not attending schools, a pattern similar to previous episodes of social isolation associated with epidemics and pandemics.⁴²

The results show an impact on mental health and physical activity mainly in the adolescent population. However, likely, these factors have also affected younger children, a fact that needs to be assessed in future studies. Another review on the impact of COVID-19 on families and children found an increase in parental stress related to the suspension of classroom activities, social isolation measures, nutritional risks, children’s exposure to toxic stress, depressive and anxiety symptoms, especially in previously unstructured homes, and a lack of physical activities.⁴³ Some cross-sectional reports found important differences between households of different socioeconomic status regarding home learning and with important potential implications for the long-term impact that the unprecedented circumstances.⁴⁴ Moreover, some studies carried out modelizations on the impact of inequalities and lost school learning. Christakis et al.⁴⁵ compared the full distribution of estimated years of life lost (YLL) due to COVID-19 under both “schools open” and “schools closed” conditions, and observed a 98.1% probability that school opening would have been associated with a lower total YLL than school closure. On the other hand Azevedo et al.⁴⁶ found that between 0.3 and 0.9 years of schooling losses adjusted for quality, bringing down the effective years of basic schooling that students achieve during their lifetime from 7.9 years to between 7.0 and 7.6 years. This would be associated with lost earnings in the amount between \$6,472 and \$25,680 dollars over a typical student's lifetime, exacerbating inequalities.

Strengths and Limitations

One of the strengths of this narrative review is the inclusion of peer-reviewed, longitudinal data, or repeated cross-sectional data based on comparable measures. This makes the association between exposure to lockdown and school closure and outcome measures analyzed more robust. Nonetheless, there are limitations. First, few of the studies analyzed data from low- and middle-income countries, or social inequalities as independent factors, which should be addressed in future studies. Second, the exposure measures that we analyzed, both school closure and lockdown, varied between countries and also the period from the beginning of the measures and the time outcomes were assessed. This fact makes it difficult to evaluate the impact according to the level and duration of confinement and also to establish a clear association between exposure and outcomes. However, all the included studies present at least the timeline for initiating the measures adopted and evaluating the results. Third, educational, healthcare, and redistributive policies before the pandemic conditioned each country's responses and results, and these factors must also be taken into account in future studies. Finally, the measures analyzed here may have long term effects and therefore future studies will need to factor in longer follow up.

Conclusions

This narrative review attempted to provide the best available evidence on the impact of pandemic related restrictive measures on child and adolescent health. The findings call for the attention of decision-makers to take into account the risks and benefits for children's health, with respect to public health measures that are adopted. Policy makers and researchers should look to other much less disruptive social distancing interventions given that lockdown measures greatly affect children and with more negative effects than benefits in the short and probably also in the long term. As other public health experts are urging,⁴⁷ we suggest that a comprehensive public health approach is needed in response to this pandemic with particular attention given to children. Social determinants and medical requirements should be addressed simultaneously, with equity and human rights as overarching principles.

Contributors

LR, PB, and AH conceptualized the paper, reviewed full-text articles, extracted the data, and wrote the first draft of the manuscript. GG, SR, and OK contributed to searches and screening of papers and helped to revise the paper and consider implications. All authors contributed to revision of the final version of the manuscript.

Declaration of interest

We declare no competing interest

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Figure 1. Flow diagram of Search and Study Inclusion Process

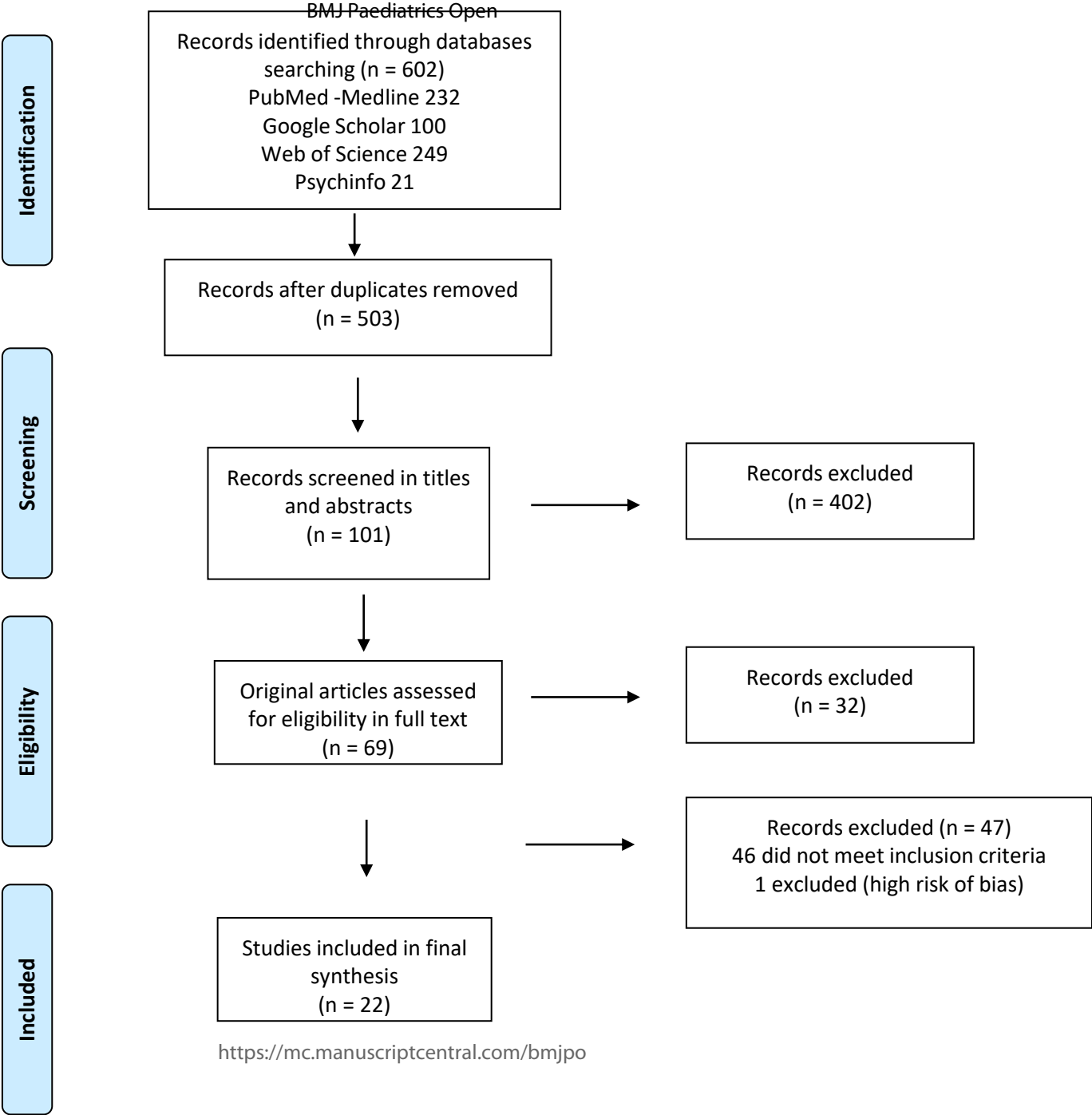


Table 1 Supplementary material
Mixed Methods Assessment Tool (MMAT) risk of bias
Magson NR, et al. ¹

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		81.8% Caucasian, and middle-high socioeconomic status 79.2%.
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?			X	
	3.3. Are there complete outcome data?			X	Response rate 53% (248 out of 467)
	3.4. Are the confounders accounted for in the design and analysis?			X	
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate risk				

Ezpeleta L, et al. ²

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		Attrition was higher among those in lower SES
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?			X	
	3.3. Are there complete outcome data?			X	55% answered the questionnaires
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate risk				

Zhang L, et al. ³

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		59.3% male
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Low risk				

Chahal R, et al. ⁴

		Yes	No	Can't tell	Comments
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Quantitative non-randomized	3.1. Are the participants representative of the target population?		X		190 out of 214 recruited, 17 excluded due to motion and image quality 102 provided complete survey data, 86 had usable resting state data, did not answer 85 adolescents (49 female) mean 11.3 yrs
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?		X		Participants retrospectively rated their levels of emotions and worries in the 3 months before COVID and 2 most recent weeks during the pandemic. Pubertal staging was administered at baseline, not at COVID assessment since the sample had a mean age of 16.5 years during the COVID-19 ECN coherence measure was obtained only at baseline
	3.3. Are there complete outcome data?		X		
	3.4. Are the confounders accounted for in the design and analysis?		X		
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?		X		T1 baseline fMRI, completed a survey in April 3-April 20, 2020 (2.5-4.5 weeks after the pandemic) The interval ranged from 3.7 to 6.5 years (mean 5.2 years)
Risk of bias	High risk. Excluded from the final synthesis				

Isumi A, et al. ⁵

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	No stratification for <10 yrs, 10-14 yrs, and 15-19 yrs
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Tromans S, et al. ⁶

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Data based on administrative data.
	4.2. Is the sample representative of the target population?			X	Mental health service utilization in UK, Leicester city Child and adolescent mental health services n=14

					The data reported is from a single healthcare trust in England, and thus may not be generalizable to all regions. It was not possible to examine the sociodemographic or clinical factors of patients referred or admitted. It might be considered that patients being admitted to mental health services are those with higher or immediate needs. These are all written in limitations
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?			X	N= 14 (small sample size)
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Physical activity, Obesity

Zenic N, et al. ⁷

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?			X	There are no dropouts reported? This is not discussed
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?		X		Self-reported physical activity
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate. It does not seem altogether unlikely that self-reported measures are affected by the special COVID-19 situation and that those lost to follow-up had different trajectories than those that participated.				

Gilic B, et al. ⁸

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		65% residing in urban centers and follow up testing included adolescents who can use their own technological resources (those who have smart phones, and computers). Regarding socioeconomic status (urban centers, use of technology are a risk to be not representative
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			

	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate				

Pietrobelli A, et al. ⁹

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		Verona, Italy, longitudinal observational study (OBELIX). Non-adult participants with obesity (BMI>25 kg/m2) N=41 children, 35 Italy, 4 North Africa, 2 Albania It is a very small sample.
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?		X		Anthropometric measurements at baseline only. No structured questionnaire. Only a survey on eating and sedentary behaviors while the rest of variable collected at baseline
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?		X		
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate -High				

Li M, et al. ¹⁰

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	Hospital based study (only one hospital) in Hubei Province China (age 18-50 yrs pregnant women)
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Brenner A, et al.¹¹

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?			X	Patient cohort where only one out of six participated. No attrition analysis.
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate. Main outcome measures are calculated within the same individuals. Should not be very sensitive to non-representativity of study population.				

Christoforidis A, et al.¹²

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?			X	Patient cohort of 34 children. A number of exclusion criteria are reported, including "unwillingness" but the number excluded is not reported
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate. Main outcome measures are calculated within the same individuals. Should not be very sensitive to non-representativity of study population.				

Di Dalmazzi G, et al.¹³

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		Italy, S.Orsola Policlinic. 130 consecutive patients with T1D wearing CGM system (30 children <12 yrs), 24 teenagers (13-17 yrs), glucose data The sample size is small and a very selected group (those under CGM monitoring and with sensor use of >70%). So, results cannot be extended to all patients with T1DM
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?			X	
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?		X		Clustering only in adult patients
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate				

Keays G, et al.¹⁴

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	28 yrs injury related ED visits Montreal Children's Hospital (one hospital), provincially designated pediatric trauma center. The study relied on data from one hospital
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Cheek JA, et al.¹⁵

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study.
	4.2. Is the sample representative of the target population?			X	Australia, pediatric ED visits. Two tertiary and 2 urban district hospitals in Victoria. The data reported from 4 centers, and the numbers of mental health and neonatal presentations are small, not sure to be generalizable
	4.3. Are the measurements appropriate?	X			Pediatric ED presentations. Mental health patients. Neonatal presentations
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Palladino F, et al.¹⁶

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	South Italy, ED of a single center 4-14 years, seizures, n=57, median age 8 yrs

					The data is from a single center and small sample size, probably not generalizable
	4.3. Are the measurements appropriate?			X	Demographic, seizures semiology, treatment ED data base and medical records MMD (media use) elaborated by adapting others validated questionnaires?
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Dopfer C, et al.¹⁷

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Ecological register study of total population in catchment area
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low				

Valitutti F, et al.¹⁸

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Ecological register study of total population in catchment area
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?		X		Appropriate, but poorly defined. Dependent on nurses judgement, could easily change over time with decreased load of patients. Decrease in percentage of total number of patients is used as outcome, is not OK. Should be population bases
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			

Risk of bias	Moderate				
Chandir S, et al. ¹⁹					
Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?		X		The study contains data on two levels, region and individual but is analyzed as one level.
Risk of bias	Low for crude analyses of change, Moderate for multivariate analysis.				

Chelo D, et al. ²⁰					
Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Ecological register study of total population in catchment area
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?	X			Cause of deaths were not registered for those who arrived dead at hospital. This is appropriately discussed
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low				

Violence, abuse against children

Garstang J, et al.²¹

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	Most severe (hospital cases) injuries were not included

	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low				

Kovler ML, et al. ²²

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	Maryland, Physical child abuse related injuries (n=8) 75% black, median age 11.5 months. This study is limited by the short period of retrospective review, and thus by the small number of patients included. Both regional and nationwide data would be needed to be compiled, and to determine if the measure taken to fight the Covid-19 pandemic is broadly associated with increased physical child abuse with more certainty.
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Baron EJ, et al. ²³

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Study based on administrative data
	4.2. Is the sample representative of the target population?			X	The data come from one State. Difficulties to know whether the results are externally valid and comparable to other counties and the US.
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			

	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low- moderate				

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Impact of lockdown and school closure on children's health and well-being during the first wave of COVID-19: a narrative review

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Abstract:

Background: In the context of containment measures against the COVID-19 pandemic the aims were to examine the impact of lockdown and school closures on child and adolescent health and well-being and social inequalities in health.

Methods: Literature review by searching five databases until November 2020. We included quantitative peer-reviewed studies reporting health and well-being outcomes in children (0-18 years) related to closure measures' impact due to COVID-19. A pair of authors assessed the risk of bias of included studies. A descriptive and narrative synthesis was carried out.

Findings: Twenty-two studies, including high-, middle- and low-income countries, fulfilled our search criteria and were judged not to have an increased risk of bias. Studies from Australia, Spain and China showed an increase in depressive symptoms, and decrease in life satisfaction. A decrease in physical activity and increase in unhealthy food consumption was shown in studies from two countries. There was a decrease in the number of visits to the emergency department in four countries, an increase in child mortality in Cameroon, and a decrease by over 50% of immunisations administered in Pakistan. A significant drop of 39% in child protection medical examination referrals during 2020 compared with previous years was found in the United Kingdom, a decrease in allegations of child abuse and neglect by almost one-third due to school closures in Florida, and an increase in the number of children with physical child abuse trauma was found in one centre in the United States.

Interpretation: From available reports, pandemic school closure and lockdown have adverse effects on child health and well-being in the short- and probably long-term. We urge governments to take the negative public health consequences into account before adopting restrictive measures in childhood.

Keywords: adolescents; children health; COVID-19; lockdown; school closure, social inequalities

Number of words in the text: 3065
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Tables: 5

What is already known

- School closure and lockdown were measures initially adopted almost worldwide in the first wave to fight the COVID-19 pandemic
- Lockdown and school closure cause disproportionate impacts on the most vulnerable populations
- Decisions on how to apply quarantine and school closures should be based on the best available evidence

What this study adds

- The negative impact of school closures and lockdown has been felt by children across diverse geographies, involving high and low income settings

- Containment measures have produced a range of adverse effects including an increase in depressive symptoms, decrease in satisfaction with life, decrease in immunisation and an increase in unhealthy lifestyle
- Along with a decrease in emergency presentations, there was also a significant decrease in the number of child abuse and neglect allegations and child protection medical assessments

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Introduction

The global COVID-19 pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the largest since the Spanish flu pandemic in 1918, with almost 100 million confirmed cases and over two million deaths.¹ This virus impacts relatively few children in terms of severe morbidity or mortality; however, they experience heightened adversity as governments intervene with drastic social control measures.² Over 1.5 billion children were out of school during the first peak, and economic insecurity has affected the most vulnerable, with several potential adverse effects.³

Governments around the world have reacted in variable ways with strategies to mitigate the pandemic. A review on the effect of school closure in the transmission of the SARS-CoV-2 in the general population predicted that school closures alone would prevent only 2–4% of deaths, much less than other social distancing interventions.⁴ On the other hand, school closures carry high social and economic costs for people across communities associated with interrupted learning, poor nutrition, gaps in childcare, the unintended strain on healthcare systems, rise in dropout rates from school, and social isolation, among other effects.⁵

The pandemic is a universal crisis that has affected all population groups across the globe. For some children, the impact could be lifelong, particularly the most vulnerable groups and those with less economic, educational and social resources.⁶ In response to school closures and depending on settings, online teaching accentuated the digital divides between those who have access and those without access.⁷ Moreover, schools have health promotion potential by implementing diverse health interventions and opportunities to advocate for reforms and innovations to promote all students' health.⁸ Arguments over whether to close schools or not to prevent transmission during a pandemic need to weigh in the potential health promotional benefits for children by attending school, in particular those in vulnerable situations. This disconnect needs to be addressed with closer cooperation that would revitalize not only their educational potential but also child and adolescent health and wellbeing^{9, 10}

Large-scale “lockdowns” as occurred with little warning in many countries, involving the complete shutting down of all economic activity, along with stringent travel bans, with punitive action for any violation, have been shown to cause disproportionate impact on the most vulnerable populations, e.g., in India.¹¹ Decisions on how to apply quarantine and school closure should be based on the best available evidence. In situations where quarantine is deemed necessary, officials should quarantine individuals no longer than required, provide clear rationale for quarantine and information about protocols, and ensure sufficient supplies are provided.¹² In summary, during the fight against coronavirus in several countries, while adopting social distancing measures in order to reduce the spread of a disease that mainly causes direct harm to adults, children’s needs have not been taken into due consideration.¹³ For children, the risks of such measures might be greater and have a potential for short- and long-term negative effect, mostly in low- and middle-income countries, but also in high-income countries, and especially in the prenatal and in early childhood periods.¹⁴

At the current stage of the pandemic it is important to summarize and compile existing information on the pandemic’s impact on child health given the measures that have been taken. The aim of this narrative review is therefore to study the impact of COVID-19 lockdown measures and school closures on child and adolescent health and well-being. Our research questions were: a) What impact do lockdowns and closure of schools have on child health and well-being?; and b) to what extent do the effects of confinement increase social inequalities in child health?

Methods

A literature review was carried out by search in PubMed, Medline, Psychinfo, Web of Science, and Google Scholar, using the following terms: “(Lockdown OR School closure) AND (COVID-19 OR SARS-CoV-2) AND (children OR adolescent) AND (secondary effects OR physical OR mental)”. Secondary hand search also was done. The time period analyzed was December 1th 2019 until November 24th 2020.

The research questions followed the Population Intervention Comparison Outcome (PICO) tool:¹⁵ P= 0-18 years, I= school closures and /or lockdown due to COVID 19; C= a comparison group—could be compared to same population before or unexposed population as control, O= physical, developmental or mental health, psychosocial (would include child maltreatment, domestic violence, violence, etc), access and use of healthcare services.

The Preferred Reporting Items of Systematic reviews Meta-Analyses (PRISMA, <http://www.prisma-statement.org/>) guideline was followed, although some items were not applicable given the characteristics of included studies.

The risk of bias of each included study was assessed by a pair of authors (PB, AH, LR) using the Mixed Methods Appraisal Tool (MMAT),¹⁶ and was further stratified as low, intermediate or high risk by consensus of each pair of authors. In the first step the risk of bias of each study was independently assessed, and in the second step a consensus was achieved according to the number and characteristics of negative scores.

Inclusion criteria: All quantitative studies from peer review literature describing studies that provided primary data about child (0-18 years) health and well-being related to the measures of school closure and any level of lockdown adopted regarding of COVID-19 and the impact on child health were included. Articles in Catalan, Danish, English, French, German, Icelandic, Italian, Norwegian, Spanish, Portuguese, Swedish and Turkish were included in the first screening. Following the initial screening, all included articles in the study were published in English language journals. Original studies (cohort studies, repeated cross-sectional studies, etc.) were included if they reported children's data. We also included studies on changes in access/use of healthcare services during a lockdown.

Exclusion criteria: Studies that did not present separate data on childhood population, as well as commentaries, theoretical frameworks, without the analysis of empirical data, and pre-print not peer-reviewed articles were excluded. Comments not based on specific empirical data (e.g., opinion papers, protocols, letters without specific reviewed data) were also left out. Further, articles regarding clinical manifestations and school transmission of COVID-19 impact on adults (i.e. teachers, parents, except if it included specifically secondary impact on children), and cross-sectional studies analyzing retrospective data without comparison or control group were also excluded.

Procedures: Abstracts obtained by the initial search strategy were assessed for possible inclusion by at least two authors. Full-text papers of the studies were obtained in doubtful cases and independently evaluated by the authors. Differences of opinion on inclusion was decided by discussion and consensus among all authors (i.e., one study that was initially included in the first screening was excluded by agreement of the authors due to a high risk of bias associated to the type of study and data collection; see the Supplementary material).

Data extraction: LR led data extraction that was checked initially by AH and PB, followed by a consensus with the rest of the authors. Data extraction included a summary of findings to answer the research questions and characteristics of the included studies: author; setting

(country: international, national or regional study); type of study; age(s); lockdown (time in days/months); school closure and lockdown (time period); type of outcome; impact on child health, and social inequalities.

Analysis: A meta-analysis was not possible to carry out given the nature of the study design and heterogeneity of the findings. Consequently, the authors carried out a descriptive and narrative synthesis of the results. First, studies were grouped according to their main subject and methodological similarities. LR, AH, and PB identified the thematic content and described the results, followed by discussion among all the authors. The results were then analysed and summarised to distill out findings to subsequently integrate those with the rest of studies.

Results

Study selection and risk of bias.

After excluding one study due to a high risk of bias¹⁷, 22 studies were included in the synthesis (Figure 1). Included studies were from 15 countries, thereof 11 European. Eleven studies were a follow-up of children, while the rest of the studies analyzed clinical databases, mortality registers, or registries on child abuse and maltreatment.

Almost all of the included studies showed low to moderate risk of bias, except one study that was considered as moderate-high risk of bias; the sample was small, an unstructured questionnaire was administered, anthropometric measurements were taken at baseline only, and measures used were not appropriate for age (Table 1 Supplementary material).¹⁸

Exposure measure (Box 1)

School closure was the most commonly adopted restrictive measure, although in most countries closure of schools and home confinement were both implemented at the same time; in some cases the latter was established as a mandatory norm and especially for the child population, and in other cases it was given as a general recommendation. The impact of school closure and lockdown or any measure of restriction such as stay-at-home, mandatory or recommended, was assessed between 2 weeks and 2-3 months after implementing these measures.

Box 1. Definitions of lockdown and school closure

- Although the term lockdown is not well-defined, it is used to nominate any measure adopted to contain the pandemic employing social distancing measures
- Lockdown measures range considerably, from mandatory total confinement in the home during prolonged periods to be only a recommendation to reduce social interactions and avoid non-essential work as much as possible
- School closure and online classes or home-schooling was the measure adopted in almost all cases during the first wave of the COVID-19 for primary and secondary schools in all included studies

Outcome measures

Five studies addressed mental health,^{19–23} three studies analyzed physical activity and obesity,^{18,24,25} three studies examined diabetes mellitus,^{26–28} eight studies approached changes in the access and use of healthcare services,^{29–36} while three studies analysed data regarding child abuse and violence.^{37–39}

Mental health (Table 1)

One Australian study showed a significant increase in depressive symptoms and anxiety and a significant decrease in life satisfaction during school closure and lockdown, mainly in girls.¹⁹ A

Spanish study gave evidence to a worse total difficulties score of the Strengths and Difficulties Questionnaire (SDQ) according to parent-proxy responses.²⁰ A cohort of Chinese children and adolescents showed that all indicators of depressive symptoms (nonsuicidal self-injury, suicide ideation, a suicide plan, and suicide attempt) deteriorated significantly during lockdown compared to previous baseline data.²¹ No difference in the number of suicides was found in a Japanese study.²² Referrals to the mental healthcare services for children and adolescents decreased during the lockdown in England compared with the previous year.²³

Physical activity, obesity (Table 2)

A decrease in physical activity level (PAL) was found in a child cohort from Croatia (from 2.97 to 2.63, $p < 0.01$) and significant differences were observed between adolescents living in urban and rural environments.²⁴ A study from Bosnia & Herzegovina found that 50% of adolescents achieved sufficient PAL at baseline, while 24% at the time of follow-up measurement during lockdown; moreover, paternal education level was associated with PAL during lockdown (OR: 1.33, 95% CI: 1.19–2.01).²⁵ The follow-up of Italian obese adolescents found that the number of meals per day increased by 1.15 ± 1.56 ($p < 0.001$) during the lockdown and also unhealthy food consumption and sedentary behaviours.¹⁸

Diabetes mellitus (Table 3)

Three studies on children with Type 1 Diabetes Mellitus (T1DM) from Israel,²⁶ Greece,²⁷ and Italy²⁸ showed no changes or improvements in glucose control indicators. However, in some cases, younger age and low family socioeconomic status was associated with worse control during the lockdown period.

Healthcare services access/use (Table 4)

There were no differences in the proportion of Caesarean deliveries (CD) between the observation and control groups in a Chinese study. Further, birth weight in the observation group during lockdown was higher than in the control group among infants born > 34 gestational weeks.²⁹

In Canada, the number of visits to the emergency department (ED) due to injuries in children decreased in 2 months in 2020 compared to the same period from 1993-2019.³⁰ An increase in the number of admissions due to seizures was found in an Italian children's hospital.³² In another Italian study, the mean pediatric ED daily consultations decreased from 326.3 (95% CI 299.9–352.7) in March-May 2019 to 101.4 (95% CI 77.9–124.9) in the same period in 2020 ($p < 0.001$).³⁴

Similarly, a decrease in the number of visits by 63.8% to the ED was observed compared with the same period in 2019 in a German hospital except for malignant/neoplastic diseases.³³ An Australian study found a 47.2% decrease in total visits to the ED (26,871 vs 14,170), with a significant difference in daily mean. Conversely, there was a 35% (485 vs 656) increase in mental health diagnoses, while neonatal visits did not change significantly.³¹

There was a 52.5% decline in the daily average of the total number of vaccinations administered during lockdown than baseline data in Pakistan.³⁵ A study from Cameroon showed a drastic drop in hospitalizations, and child mortality rates doubled comparing with the previous year.³⁶

Violence, abuse against children (Table 5)

Routinely collected clinical data on Child Protection Medical Examinations from Birmingham (UK) showed a significant drop of 39% (95% CI 14% to 57%) in child protection medical examination (CPME) referrals during 2020 compared with previous years, mainly associated

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with decreased school staff referrals.³⁷ A study from the US found an increase in the number of children with physical child abuse trauma,³⁸ and the Florida child abuse allegation data showed a decrease in 27% (n= 15,000) in the number of allegations of child abuse and neglect comparing with the same two months of 2019.³⁹

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Table 1. Studies on mental health and general health

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
NR, et al. (J Youth Adolesc)	Australia (New South Wales)	Cohort study (Risks to Adolescent Wellbeing Project, the RAW Project)	Mental health, life satisfaction	To assess the impact of the COVID-19 pandemic on adolescents' mental health, and moderators of change, as well as assessing the factors perceived as causing the most distress.	13-16y (response rate 53% at time T2 during lockdown, n=248)	T1= previous year (2019) T2= 2 months after start lockdown) May 5 to May 14	Generalized Anxiety, Depressive symptoms, Student's Life Satisfaction Scale (SLSS)	Age, sex, schooling, peer and family relationships, social connection, media exposure, COVID-19 related stress, and adherence to government stay-at-home directives at T2	Significant increase in depressive symptoms and anxiety, and a significant decrease in life satisfaction from T1 to T2, higher among girls. Moderators were COVID-19 related worries, online learning difficulties, and increased conflict with parents as predictors of increases in mental health problems from T1 to T2. Adherence to stay-at-home and feeling socially connected during the lockdown protected against poor mental health.
Ezpeleta L, et al. (Int J Environ Res Public Health) ²⁰	Barcelona (Spain)	Cohort study (started 10 years ago)	Mental health	To assess life conditions during lockdown associated with mental health problems in children, and to analyze the mental health status of the population during the lockdown period.	226 parents (mainly mothers) answered the questionnaire (response rate 55%). Mean age= 13.9y	Lockdown March 13 to May 24. Questionnaires answered on June. Compare results with 2019	SDQ parent-proxy version	Physical environment, COVID-19 disease, the adults sharing the house, adolescents' relationships, activities, and feelings/behaviors	Total difficulties increased and peer, and prosocial, after adjusting for previous pathology. Effect size small to medium.
Zhang L, et al. (JAMA Net Open) ²¹	China (Chizhou, Anhui Province)	Cohort	Mental health	To investigate psychological symptoms, nonsuicidal self-injury, and suicidal ideation, plans, and attempts among a cohort of children and adolescents	Age range 9:3-15:9. Mean age: 12.6y 4th to 8th grades. N= 1241 out of 1387 participant	2 waves: wave 1, early November 2019; and 2 weeks after school reopening (wave 2, mid-May 2020). After 3 months of lockdown, schools in Chizhou were reopened	Data on depressive and anxious symptoms (Mood and Feelings Questionnaire (MFQ); MacArthur Health & Behavior Questionnaire), nonsuicidal self-injury (NSSI), suicide ideation, suicide plan, and suicide	Adjusting for age, sex, body mass index, self-perceived household economic status, family cohesion, parental conflict, academic stress, parental educational level, family adverse life events, self-perceived health, sleep	The prevalence of mental health outcomes among students in wave 2 increased significantly from levels at wave 1: depressive symptoms (24.9% vs 18.5%; adjusted odds ratio [aOR], 1.50 [95% CI, 1.18-1.90]; nonsuicidal self-injury

					s in 2 waves	on April 26	attempt were collected in 2 waves	duration, and sleep disorders.	(42.0% vs 31.8%; aOR, 1.35 [95% CI, 1.17-1.55]°; suicide ideation (29.7% vs 22.5% aOR, 1.32 [95%CI, 1.08-1.62]; suicide plan (14.6% vs 8.7%; aOR, 1.71 [95% CI, 1.31-2.24]; and suicide attempt (6.4% vs 3.0% aOR, 1.74 [95% CI, 1.14-2.67]. No differences in anxiety symptoms.
Tromans S, et al. (Br J Psy Open) ²³	Leicester -UK	Electronic data register of aprox. 1,000,000 hab of the NHS	Mental health	To describe secondary mental health service utilization prelockdown and during lockdown	Grat population. Children and adolescents' mental healthcare services (CAMHS)	Jan 27-March 22 compared to 23 March 23, May 17 (lockdown)	Mental health admissions and referrals		Admissions pre-lockdown n=14; lockdown n=17, referrals pre-lockdown n=2193; lockdown n=1081.
Isumi A, et al. (Child Abuse Negl) ²²	Japan	Data on mortality by age in Japan	Suicides	To investigates the acute effect of the first wave of the COVID-19 pandemic on suicide among children and adolescents during school closure in Japan.	Total number of suicides among children <20y	School closure March-May 2020. Compare March to May 2020 with the same data on 2018 and 2019	Suicide Incidence rate ratio (IRR) by month		No change in suicide rates during the school closure (incidence rate ratio (IRR)=1.15, 95% CI: 0.81 to 1.64) and no interaction with school closure.

Table 2. Studies on physical activity/obesity studies

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Zenic N, et al. (Appl Sci) ²⁴	Croatia	Follow-up	Physical activity (PA)	To evaluate the changes in PAL and factors associated with PALs	N= 823; Mean age=16.5y	“Social distancing measures”: March 15. T1: October 2019 to March 2020 and T2 April 2020	Anthropometrics, physical fitness status, and evaluation of PALs (Physical Activity Questionnaire for Adolescents, PAQA) evaluated by an internet application	Urban vs rural	A decrease in PAL for the total sample (from 2.97 to 2.63, $p<0.01$) and mainly in urban adolescents (from 3.11 to 2.68, $p<0.001$). Significant differences between adolescents living in urban and rural environments were observed for baseline-PAL.
Gilic B, et al. (Child (Basel)) ²⁵	Bosnia & Herzegovina	Follow-up pre and during pandemic	Physical activity level (PAL)	Changes in PAL among adolescents from Bosnia and Herzegovina and to evaluate sociodemographic and parental/familial factors which may influence PAL before and during the COVID-19 pandemic and imposed lockdown.	N= 688 adolescents (322 females), mean age 17y at the baseline (15–18y), attending high school. N=794 baseline F-up= 695	Baseline Jan 6-12 Lockdown March 16 Follow-up April 20-26	The Physical Activity Questionnaire for Adolescents (PAQ-A)	Parental education level, income level, family conflicts	50% of adolescents underwent sufficient PAL at baseline, while only 24% of them were achieving sufficient PAL at the time of follow-up measurement. Paternal level of education was associated to PAL during lockdown (OR: 1.33, 95% CI: 1.19–2.01).
Pietrobelli A, et al. (Obesity Spring) ¹⁸	Italy (verona)	Longitudinal observational study-OBELIX Study	Obesity	To analyze if youths with obesity, when removed from structured school activities and confined to their homes during the COVID-19 pandemic, will display unfavorable trends in lifestyle behaviors.	N=41 out of 50. Mean age 13.0±3.1y	Children enrolled between May 13th and July 30th, 2019. The interviews were conducted at the baseline visit and again three weeks following the mandatory quarantine starting on March 10th, 2020.	Body weight, height, and waist circumference were measured at the baseline visit; BMI was calculated	Gender differences	The number of meals eaten per day increased by 1.15 ± 1.56 ($p<0.001$). Sleep time increased significantly (0.65 ± 1.29 hours/day, $p=0.003$) and sports time decreased significantly by 2.30 ± 4.60 hours/week ($p=0.003$). Screen time increased by 4.85 ± 2.40 hours/day ($p<0.001$). There was an inverse correlation between change in sports participation and both a change in number of meals/day and in screen time

									($r=-0.27$, borderline significant at $p=0.084$). The number of meals eaten per day increased significantly more in the males than in females.
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Table 3. Studies on diabetes mellitus

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Brener A, et al. (Acta Diabetol) ²⁶	Israel	Follow-up	Clinical control of T1D	To assess the impact of COVID-19 lockdown on the glycemic control of pediatric patients with T1D.	102 T1DM patients (52.9% males), mean age 11.2y, mean diabetes duration 4.2y	From February 23, 2020 to March 7, 2020 and during the lockdown from March 25, 2020 to April 7, 2020.	Mean glucose level, time-in-range (TIR, 70–180 mg/dL; 3.9–10 mmol/L), hypoglycemia (<54 mg/dL; <3 mmol/L), hyperglycemia (>250 mg/dL; >13.3 mmol/L), coefficient of variation (CV), and time CGM active before and during lockdown.	Age, sex, households (single/two parents)], socioeconomic position by home address SEP cluster and SEP index	In the younger age group, a multiple linear regression model revealed associations of age and lower SEP cluster with delta-TIR ($F = 4.416$, $p=0.019$) and with delta-mean glucose ($F = 4.459$, $p=0.018$). No significant correlations were found in the adolescent age group.
Christoforidis A, et al. (Diabetes Res Clin Pract) ²⁷	Greece	Follow-up	T1DM control	To monitor the effect of the lockdown in glycemic variability, insulin requirements and eating portions and habits in children with T1DM wearing insulin pump equipped with a continuous glucose monitoring system	34 out of 250 children with T1DM, mean age= 11.3y	3 weeks before and 3 weeks after March 10 (starting lockdown and school closure)	Control of insulin pump equipped and glucose metabolism		A higher Coefficient of Variation (CV) indicating an increased glucose variability in the pre-lockdown period was observed (39.52% versus 37.40%, $p=0.011$). No significant difference was recorded regarding the total daily dose of insulin and the reported carbohydrates consumed, however, meal schedule has changed.
Di Dalmazi G, et al. (BMJ Open Diabetes Res Care) ²⁸	Italy (Orsola Policlinic, Bologna)	A cohort of DM-1	Clinical control in diabetics	To investigate continuous glucose monitoring (CGM) metrics in children and adults with T1D during lockdown and to identify their	130 consecutive patients with T1DM (30 children (≤12 years), 24	Before the lockdown in Italy, from 20 February to 10 March 2020, and also January 30 to February 19 (pre-lockdown) and 20 days starting from that date,	Outcome measures: index of glucose control: GMI, LBG index, etc		In children, significantly lower (improvement) glucose SD (SDglu) ($p=0.029$) and time below range (TBR) <54 mg/dL (TBR2) ($p=0.029$) were detected after lockdown. CGM metrics

				potentially related factors.	teenagers (13–17 years),	from 11 to 30 March 2020 (during lockdown).			were comparable in teenagers before and during lockdown.
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Table 4. Studies on accessing healthcare services

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Li M, et al. (PlosOne) ²⁹	China (Wuhan)	Analysis of register of perinatal data	Perinatal services	To compare the indications for cesarean delivery (CD) and the birth weights of newborns during and pre-lockdown	N= 3,432 (out of 3,442) pregnant women who gave birth during lockdown and 7,159 (out of 29,799) matched pregnant before lockdown.	On January 23 2020, the municipal government of Wuhan announced the lockdown of the entire city. Data was collected until March 14. Control group: from January 1, 2019 to January 22, 2020.	Type of delivery. The neonates' data including birth weight, clinical symptoms, Apgar score, and outcomes		There was no differences in CD between the observation and control groups. Birth weight in the observation group was heavier than that in the control group among those with >34 gestational weeks (p<0.05). There was no significant difference in neonatal asphyxia between the two groups.
Keays G, et al. (Health Promot Chronic Dis Prev Can) ³⁰	Canada (Montreal Children's Hospital)	Data from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP)	Use of healthcare services (ED)	To evaluate if injury-related ED visits during the COVID-19 pandemic decrease.	General population stratified by age	Compare data from a two-months period during the COVID-19 lockdown (March 16 to May 15) to the same period in previous years (1993–2019).	Visits to ED due to injuries: motor vehicle collisions, sports-related injuries, and injuries that occurred during recreational activities.	No data	Compared with the 2015-2019 average, the decrease was smallest in children aged 2 to 5 years (35% decrease), and greatest in the group aged 12-17y (83%). More children aged 6 to 17 years presented with less urgent injuries during the COVID-19 lockdown.
Cheek JA, et al. (Emerg Med Australas) ³¹	Australia (4 hospitals from Victoria)	Analysis of ED register	Use of healthcare services (ED)	To determine if changes to community-based services have affected paediatric ED attendances for mental health issues and neonates during the COVID-19 pandemic.	<18y and neonatal visits	Closure of borders to non-residents on March 20 th 2020.	Compare total visits to the ED, visits for mental health diagnoses and neonatal visits.		There was 47.2% decrease in total presentations (26,871 vs 14,170), with significant difference in daily mean. Conversely, there was a 35% (485 vs 656) increase in mental health, while neonatal presentations did not change (2% increase, 498 vs 507).

Palladino F, et al. (Neurol Sci) ³²	Italy. Santobono-Pausilipon Children's Hospital (Southern Italy)	Repeated cross-sectional study of clinical registers	Clinical health, seizures	To compare the 2020 admissions for seizures at the ED with previous year	Patients (4–14 years) attending the ED for seizures n=57 Median age: 8.03y	Compare March 9 to up to May 4 and the same period for 2019	Diagnoses previous (epilepsy) or not	Use of devices, how contact with healthcare services	57 patients 20 of them new patients compared with 13 in 2019 and other differences.
Dopfer C, et al. (BMC Pediatr) ³³	Germany (Hanover)	Healthcare services. ED utilization	Registry of pediatric ED	To investigate pediatric emergency Healthcare utilization in a tertiary care center	N= 5424 visits in the study period. Mean age 7.1y	School closures beginning on March 16th, and an official lockdown of public life, on March 23 rd 2020. Analysis: March 18th to April 14th in 2019 and March 16th to April 12th in 2020.	Number of visits; ICD-10 diagnoses	Age, sex	In 2020, case numbers decreased by 63.8% compared to the same period of 2019. The % of visits to children <1y increased in 2020. The disease category with increased daily ER visits after the lockdown began was malignant/ neoplastic disease.
Valitutti F, et al. (Front Pediatr) ³⁴	Italy (Campania region)	Healthcare services use before after	ED registry	To highlight the impact of the COVID-19 pandemic on ED consultation	Mean age = 5.4 y in 2019 and 5.9y in 2020	Registers of trimester March-May 2019 vs. registers of trimester March-May 2020	Number of consultations, diagnoses, causes of emergency visits		Mean pediatric ED daily consultations were 326.3 (95% CI 299.9–352.7) in March–May 2019 and 101.4 (95% CI 77.9–124.9) in March–May 2020 (p < 0.001).
Chandir S, et al. (Vaccine) ³⁵	Pakistan (Sindh)	Analysis of Electronic Immunization Registry	Healthcare services. Preventive measures. Immunization	To measure the reduction in daily immunization rates in Sindh province, report antigen-wise coverage, and dropout rates for 0–23 month children, identify baseline characteristics associated with dropout, and observe the spatial distribution of immunization activity.	0–23 month children	Lockdown starting on March 23, 2020, was initially extended to May 9, 2020. It was a complete ban on movement, and exemptions were given only to essential service providers, including health (including immunization), law enforcement, utility, and telecommunications.	Primary outcome of the analysis was the receipt of EPI recommended vaccinations (BCG, polio, penta, PCV10, rotavirus, and measles) during the COVID-19 lockdown period. Analysis of data from September 23, 2019, to July 11, 2020.		There was a 52.5% decline in the daily average total number of vaccinations administered during lockdown compared to baseline. The highest decline was seen for BCG (40.6% (958/2360) immunization at fixed sites. Around 8438 children/day were missing immunization during the lockdown. Enrollments declined furthest in rural districts, urban sub-districts with large slums, and polio-endemic super high-risk sub-districts.
Chelo D, et al. (Pediatr Pathol) ³⁶	Cameroon	Before after approach	Hospitalization and mortality in the main	To analyze the consequences of the pandemic on	Children (age not specified) pediatric age	Lockdown started on March 17 th .	Hospitalization rates and mortality rates by periods		A drastic drop in hospitalization was noted coinciding with partial lockdown. At the same time, the

			pediatric hospital in Yaounde	hospitalization and on mortality in a pediatric hospital.		Analysis: 1st to 30th June, 2020 and covered the period from January 1st, 2016 to May 31st, 2020.			number of deaths per month doubled though the causes remained the same as in the past.
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Table 5. Studies on child abuse

First author (Journal)	Country (ies)	Type of study	Main Subject	Objectives	Age (n)	Lockdown /school closure and time of data collection	Outcome Measures	Other factors (inequalities)	Summary of results
Garstang J, et al. (BMJ Open) ³⁷	UK (Birmingham)	Registry of child protection	Routinely collected clinical data from Child Protection Medical Examination	To determine any change in referral patterns and outcomes in children referred for child protection medical examination (CPME) during the COVID-19 pandemic compared with previous years.	Children (0–18). N= 200 CPME	Data were collected for all CPME for 18-week periods in 2018, 2019 and 2020, from the last week in February to the end of June	Incidence rate ratios (IRR) of CPME comparing 2018–19 and 2020		A significant drop of 39% (95% CI 14% to 57%) in CPME referrals during 2020 compared with previous years. CPME 2018= 78; 2019=75; 2020= 47. Associated mainly to a school staff decreased in referrals.
Kovler ML, et al. (Child Abuse Negl) ³⁸	US (Maryland)	Clinical registry (Johns Hopkins Hospital of Maryland)	Child abuse and maltreatment	To assess the proportion of injuries secondary to physical child abuse (PCA) at a level I pediatric trauma center during the Covid-19 pandemic.	Younger than 15y	Childcare facilities closed on March 27. Analysis: March 28 to April 27 and compare with 2018 and 2019	PCA during lockdown	Age, race, severity, type of trauma	8 patients (13% of total trauma) compared to 4 (2019, 4%) and 3 (2018, 3%).
Baron EJ, et al. (J Public Econ) ³⁹	US (Florida)	Allegation data from the Florida DCF. County-level, monthly information on the total number	Child abuse and maltreatment	To analyze the Florida child abuse Hotline reported cases and compare with previous years	Children (not specific age?)	Official statewide stay-at-home order in Florida was April 3, 2020. Compare from January 2004–2019 with March and April 2020 monthly allegations	Number of reported cases associated to schools opened	Ecological data on county level of economic condition	15,000 lower (27%) than expected for these two months.

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		of allegation s of abuse, neglect, or abandon ment of children							
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Confidential: For Review Only

Discussion

This narrative review provides summaries of peer-reviewed published evidence on the impact of school closures and lockdown on child health, well-being and access to healthcare, during the first wave of COVID-19. The results show worse mental health status of children and adolescents from disparate geography and socioeconomic background, reduced physical activity and increased sedentary behaviors. There were changes in the access and use of healthcare services as manifested by decrease in the ED visits, increased child mortality in a study from Cameroon, and a reduction on immunization coverage in Pakistan. Finally, an increased risk of child abuse and violence against children due to decreased access to general and specific care services during the period of lockdown and school closure was seen in the US and UK. The effect of these measures of restriction indicates an increase in social inequalities. However, only a few of the studies focus specifically on analyzing the impact on social determinants of child health. We found a significant negative effect in the most vulnerable groups (i.e. higher mortality and less vaccination coverage in the studies from low- and middle-income countries), and more significant negative impact on mental and physical health and child abuse and maltreatment in the most vulnerable child population in studies from high-income countries.

The results of this “non-natural experiment” are generalizable to most of the countries that applied any level of lockdown or confinement and closure of schools, although each country has different healthcare and education systems, and social and redistribution policies. Confinement has produced an increase in previously existing inequalities with respect to access to basic living conditions and care services, with more difficulties in households with fewer resources.⁴⁰

The results of the present study add to previous analyses on the impact of quarantine and school closure during previous epidemic outbreaks worldwide.¹² The latter analyzed the impact and reported negative psychological effects including post-traumatic stress symptoms, confusion, and anger. On the other hand, social isolation exacerbates personal and collective vulnerabilities while limiting accessible and familiar support options.⁴¹ Many countries have seen an increase in demand for domestic violence services and reports of increased risk for children not attending schools, a pattern similar to previous episodes of social isolation associated with epidemics and pandemics.⁴²

The results show an impact on mental health and physical activity mainly in the adolescent population. However, likely, these factors have also affected younger children, a fact that needs to be assessed in future studies. Another review on the impact of COVID-19 on families and children found an increase in parental stress related to the suspension of classroom activities, social isolation measures, nutritional risks, children’s exposure to toxic stress, depressive and anxiety symptoms, especially in previously unstructured homes, and a lack of physical activities.⁴³ Some cross-sectional reports found important differences between households of different socioeconomic status regarding home learning and with important potential implications for the long-term impact that the unprecedented circumstances.⁴⁴ Moreover, some studies carried out modelizations on the impact of inequalities and lost school learning. Christakis et al.⁴⁵ compared the full distribution of estimated years of life lost (YLL) due to COVID-19 under both “schools open” and “schools closed” conditions, and observed a 98.1% probability that school opening would have been associated with a lower total YLL than school closure. On the other hand Azevedo et al.⁴⁶ found that between 0.3 and 0.9 years of schooling losses adjusted for quality, bringing down the effective years of basic schooling that students achieve during their lifetime from 7.9 years to between 7.0 and 7.6 years. This would be associated with lost earnings in the amount between \$6,472 and \$25,680 dollars over a typical student's lifetime, exacerbating inequalities.

Strengths and Limitations

One of the strengths of this narrative review is the inclusion of peer-reviewed, longitudinal data, or repeated cross-sectional data based on comparable measures. This makes the association between exposure to lockdown and school closure and outcome measures analyzed more robust. Nonetheless, there are limitations. First, few of the studies analyzed data from low- and middle-income countries, or social inequalities as independent factors, which should be addressed in future studies. Second, the exposure measures that we analyzed, both school closure and lockdown, varied between countries and also the period from the beginning of the measures and the time outcomes were assessed. This fact makes it difficult to evaluate the impact according to the level and duration of confinement and also to establish a clear association between exposure and outcomes. However, all the included studies present at least the timeline for initiating the measures adopted and evaluating the results. Third, educational, healthcare, and redistributive policies before the pandemic conditioned each country's responses and results, and these factors must also be taken into account in future studies. Finally, the measures analyzed here may have long term effects and therefore future studies will need to factor in longer follow up.

Conclusions

This narrative review attempted to provide the best available evidence on the impact of pandemic related restrictive measures on child and adolescent health. The findings call for the attention of decision-makers to take into account the risks and benefits for children's health, with respect to public health measures that are adopted. Policy makers and researchers should look to other much less disruptive social distancing interventions given that lockdown measures greatly affect children and with more negative effects than benefits in the short and probably also in the long term. As other public health experts are urging,⁴⁷ we suggest that a comprehensive public health approach is needed in response to this pandemic with particular attention given to children. Social determinants and medical requirements should be addressed simultaneously, with equity and human rights as overarching principles.

Contributors

LR, PB, and AH conceptualized the paper, reviewed full-text articles, extracted the data, and wrote the first draft of the manuscript. GG, SR, and OK contributed to searches and screening of papers and helped to revise the paper and consider implications. All authors contributed to revision of the final version of the manuscript.

Declaration of interest

We declare no competing interest

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Figure 1. Search flow.

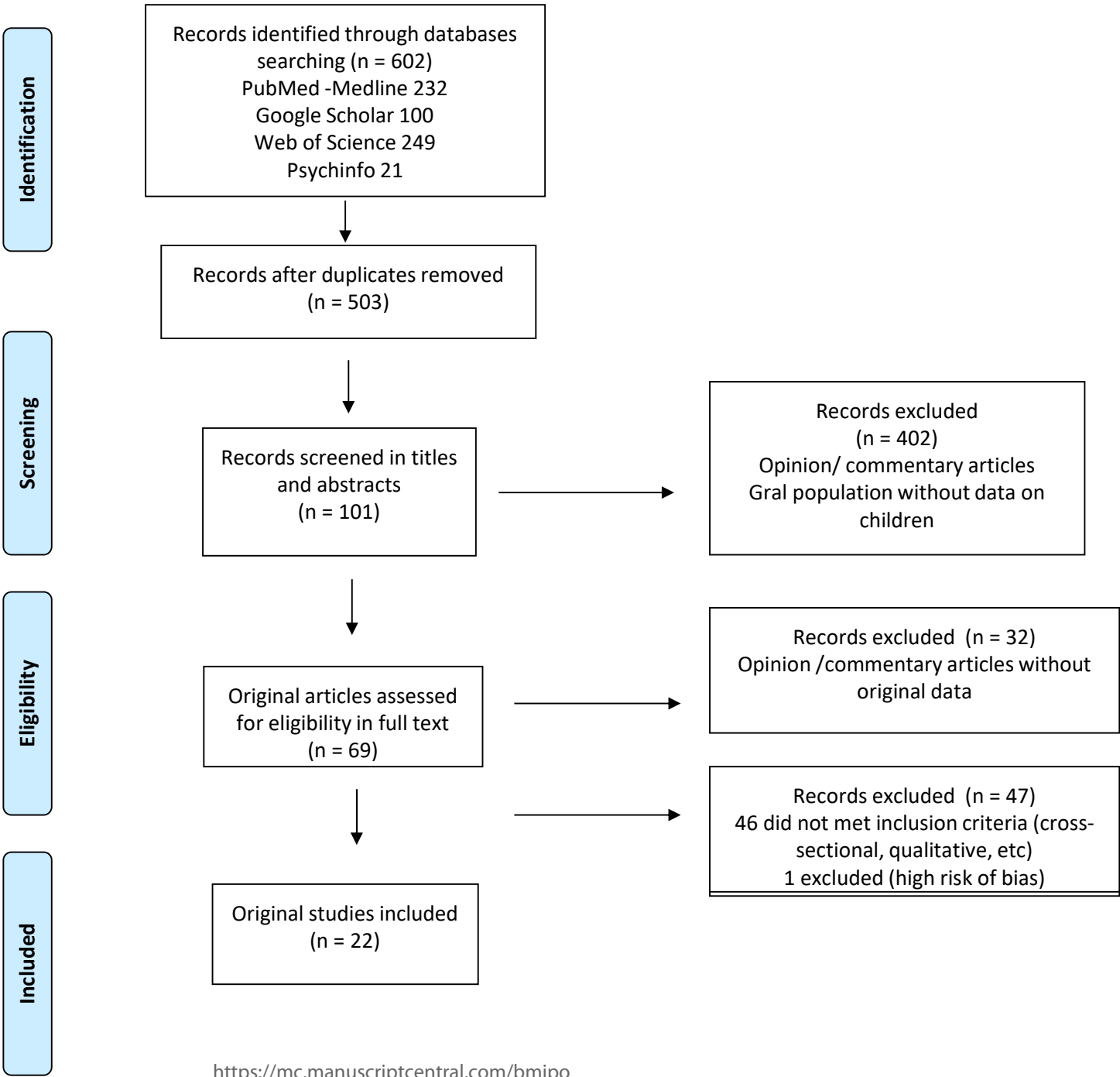


Table 1 Supplementary material
Mixed Methods Assessment Tool (MMAT) risk of bias
Magson NR, et al. ¹

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		81.8% Caucasian, and middle-high socioeconomic status 79.2%.
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?			X	
	3.3. Are there complete outcome data?			X	Response rate 53% (248 out of 467)
	3.4. Are the confounders accounted for in the design and analysis?			X	
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate risk				

Ezpeleta L, et al. ²

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		Attrition was higher among those in lower SES
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?			X	
	3.3. Are there complete outcome data?			X	55% answered the questionnaires
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate risk				

Zhang L, et al. ³

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		59.3% male
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Low risk				

Chahal R, et al. ⁴

		Yes	No	Can't tell	Comments
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Quantitative non-randomized	3.1. Are the participants representative of the target population?		X		190 out of 214 recruited, 17 excluded due to motion and image quality 102 provided complete survey data, 86 had usable resting state data, did not answer 85 adolescents (49 female) mean 11.3 yrs
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?		X		Participants retrospectively rated their levels of emotions and worries in the 3 months before COVID and 2 most recent weeks during the pandemic. Pubertal staging was administered at baseline, not at COVID assessment since the sample had a mean age of 16.5 years during the COVID-19 ECN coherence measure was obtained only at baseline
	3.3. Are there complete outcome data?		X		
	3.4. Are the confounders accounted for in the design and analysis?		X		
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?		X		T1 baseline fMRI, completed a survey in April 3-April 20, 2020 (2.5-4.5 weeks after the pandemic) The interval ranged from 3.7 to 6.5 years (mean 5.2 years)
Risk of bias	High risk. Excluded from the final synthesis				

Isumi A, et al. ⁵

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	No stratification for <10 yrs, 10-14 yrs, and 15-19 yrs
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Tromans S, et al. ⁶

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Data based on administrative data.
	4.2. Is the sample representative of the target population?			X	Mental health service utilization in UK, Leicester city Child and adolescent mental health services n=14

					The data reported is from a single healthcare trust in England, and thus may not be generalizable to all regions. It was not possible to examine the sociodemographic or clinical factors of patients referred or admitted. It might be considered that patients being admitted to mental health services are those with higher or immediate needs. These are all written in limitations
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?			X	N= 14 (small sample size)
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Physical activity, Obesity

Zenic N, et al. ⁷

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?			X	There are no dropouts reported? This is not discussed
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?		X		Self-reported physical activity
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate. It does not seem altogether unlikely that self-reported measures are affected by the special COVID-19 situation and that those lost to follow-up had different trajectories than those that participated.				

Gilic B, et al. ⁸

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		65% residing in urban centers and follow up testing included adolescents who can use their own technological resources (those who have smart phones, and computers). Regarding socioeconomic status (urban centers, use of technology are a risk to be not representative
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			

	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate				

Pietrobelli A, et al. ⁹

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		Verona, Italy, longitudinal observational study (OBELIX). Non-adult participants with obesity (BMI>25 kg/m2) N=41 children, 35 Italy, 4 North Africa, 2 Albania It is a very small sample.
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?		X		Anthropometric measurements at baseline only. No structured questionnaire. Only a survey on eating and sedentary behaviors while the rest of variable collected at baseline
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?		X		
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate -High				

Li M, et al. ¹⁰

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	Hospital based study (only one hospital) in Hubei Province China (age 18-50 yrs pregnant women)
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Brenner A, et al. ¹¹

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?			X	Patient cohort where only one out of six participated. No attrition analysis.
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate. Main outcome measures are calculated within the same individuals. Should not be very sensitive to non-representativity of study population.				

Christoforidis A, et al. ¹²

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?			X	Patient cohort of 34 children. A number of exclusion criteria are reported, including "unwillingness" but the number excluded is not reported
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	X			
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?	X			
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate. Main outcome measures are calculated within the same individuals. Should not be very sensitive to non-representativity of study population.				

Di Dalmazzi G, et al. ¹³

Quantitative non-randomized		Yes	No	Can't tell	Comments
	3.1. Are the participants representative of the target population?		X		Italy, S.Orsola Policlinic. 130 consecutive patients with T1D wearing CGM system (30 children <12 yrs), 24 teenagers (13-17 yrs), glucose data The sample size is small and a very selected group (those under CGM monitoring and with sensor use of >70%). So, results cannot be extended to all patients with T1DM
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?			X	
	3.3. Are there complete outcome data?	X			
	3.4. Are the confounders accounted for in the design and analysis?		X		Clustering only in adult patients
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	X			
Risk of bias	Moderate				

Keays G, et al. ¹⁴

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	28 yrs injury related ED visits Montreal Children's Hospital (one hospital), provincially designated pediatric trauma center. The study relied on data from one hospital
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Cheek JA, et al.¹⁵

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study.
	4.2. Is the sample representative of the target population?			X	Australia, pediatric ED visits. Two tertiary and 2 urban district hospitals in Victoria. The data reported from 4 centers, and the numbers of mental health and neonatal presentations are small, not sure to be generalizable
	4.3. Are the measurements appropriate?	X			Pediatric ED presentations. Mental health patients. Neonatal presentations
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Palladino F, et al.¹⁶

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	South Italy, ED of a single center 4-14 years, seizures, n=57, median age 8 yrs

					The data is from a single center and small sample size, probably not generalizable
	4.3. Are the measurements appropriate?			X	Demographic, seizures semiology, treatment ED data base and medical records MMD (media use) elaborated by adapting others validated questionnaires?
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Dopfer C, et al.¹⁷

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Ecological register study of total population in catchment area
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low				

Valitutti F, et al.¹⁸

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Ecological register study of total population in catchment area
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?		X		Appropriate, but poorly defined. Dependent on nurses judgement, could easily change over time with decreased load of patients. Decrease in percentage of total number of patients is used as outcome, is not OK. Should be population bases
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			

Risk of bias	Moderate				
Chandir S, et al. ¹⁹					
Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?		X		The study contains data on two levels, region and individual but is analyzed as one level.
Risk of bias	Low for crude analyses of change, Moderate for multivariate analysis.				

Chelo D, et al. ²⁰					
Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Ecological register study of total population in catchment area
	4.2. Is the sample representative of the target population?			X	
	4.3. Are the measurements appropriate?	X			Cause of deaths were not registered for those who arrived dead at hospital. This is appropriately discussed
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low				

Violence, abuse against children

Garstang J, et al.²¹

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	Most severe (hospital cases) injuries were not included

	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low				

Kovler ML, et al. ²²

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Register study
	4.2. Is the sample representative of the target population?			X	Maryland, Physical child abuse related injuries (n=8) 75% black, median age 11.5 months. This study is limited by the short period of retrospective review, and thus by the small number of patients included. Both regional and nationwide data would be needed to be compiled, and to determine if the measure taken to fight the Covid-19 pandemic is broadly associated with increased physical child abuse with more certainty.
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			
	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Moderate				

Baron EJ, et al. ²³

Descriptive study		Yes	No	Can't tell	Comments
	4.1. Is the sampling strategy relevant to address the research question?	X			Study based on administrative data
	4.2. Is the sample representative of the target population?			X	The data come from one State. Difficulties to know whether the results are externally valid and comparable to other counties and the US.
	4.3. Are the measurements appropriate?	X			
	4.4. Is the risk of nonresponse bias low?	X			

	4.5. Is the statistical analysis appropriate to answer the research question?	X			
Risk of bias	Low- moderate				

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